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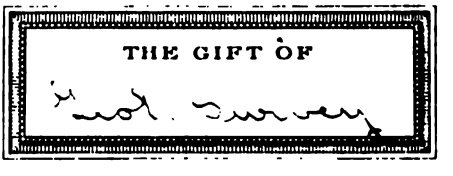
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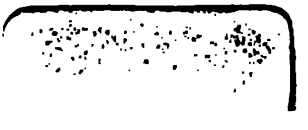

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REPORT

OF THE

STATE BOARD OF GEOLOGICAL SURVEY

OF MICHIGAN

FOR THE YEAR 1905

ALFRED C. LANE

STATE GEOLOGIST

BY AUTHORITY

LANSING, MICHIGAN
WYNKOOP HALLENBECK CRAWFORD COMPANY, STATE PRINTERS
1906

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1905

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THE PRESIDENT OF THE STATE BOARD OF EDUCATION

HON. W. J. McKONE.

From November 1, 1905.

AN ECOLOGICAL SURVEY

IN

NORTHERN MICHIGAN.

PREPARED UNDER THE DIRECTION OF

CHAS. C. ADAMS.

A Report from the University Museum, University of Michigan, published by the State Board of Geological Survey as a part of the Report for 1905.

LANSING, MICHIGAN
WYNKOOP HALLENBECK CRAWFORD CO., STATE PRINTERS
1906

LETTER OF TRANSMITTAL.

OFFICE OF THE STATE GEOLOGIST,
LANSING, MICH., Oct. 30, 1905.

To the Honorable, the Board of Geological Survey of the State of Michigan:

Hon. Fred M. Warner, President.
Hon. L. L. Wright.
Hon. Patrick H. Kelley, Secretary.

Gentlemen:—I herewith transmit for publication, in the Annual Report of the Board for 1905, the following report. This is a contribution to the Biological Survey of the State, which the Legislature authorized you to supervise and execute by Act No. 250 of the Session of 1905. The following report is the result of a natural history survey made in the Porcupine Mountains and on Isle Royale by a party from the University Museum, University of Michigan. It is not a mere list of plants and animals, but a study of these forms in relation to their surroundings. It is thus a contribution to the natural history of the Upper Peninsula, and in addition to its scientific value will, I trust, be of use to teachers in all parts of this region and stimulate them in the study of the forms of life about them.

Very respectfully,
ALFRED C. LANE.

FIG. 1. Geological map of a portion of the Porcupine Mountains, Mich.

2. Quartz-porphyry. 3. Diabase. Diabase-amygdaloid ("Trap"). 4. Sandstone and Conglomerate. 5. Diabase and Diabase-amygdaloid ("Trap") 6. Sandstone with thin bands of conglomerate. 7. Dark-grey Sandstone and Black Shale.—(After Irving).

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INTRODUCTORY NOTE.

During the summer of 1904 the University Museum of the University of Michigan sent a party to Northern Michigan. The aim of the expedition was to make an ecological study of the plant and animal life of the Porcupine Mountains in Ontonagon County and on Isle Royale. The Porcupine Mountains are about 120 miles west of Marquette, on the south shore of Lake Superior; Isle Royale, an island in Lake Superior, is near the north or Canadian shore. Almost nothing has been known of the Natural History of these localities, and collections from these regions have been almost completely lacking in the Museum. Civilization has already exterminated a large number of plants and animals from parts of Lower Michigan, so that it is especially desirable that records and collections be secured from these northern regions ere it becomes too late through the encroachments of civilization.

The expedition was made possible through the generosity of certain public spirited friends of the University, as the funds of the Museum are too limited to carry on this very important line of work, without special aid. The major part of the funds were the combined gifts of Mr. Bryant Walker, of Detroit, Hon. Peter White and Mr. N. M. Kaufman, of Marquette, and to these gentlemen in particular the University Museum is under great obligation. The Board of Regents of the University generously contributed the expense of transportation, not otherwise provided. Through the efforts of Mr. White the party received transportation or special rates in the Northern Peninsula. The Duluth, South Shore & Atlantic R. R. gave a special rate to the party, and the White Line Transportation Co., through Capt. W. H. Singer, general manager, gave free transportation to the party to and from Isle Royale. Through Mr. Henry Russel, the Michigan Central R. R. also gave the party a special rate. The Washington Club of Duluth, through Mr. John Panton, provided the party with excellent field headquarters upon their private grounds on Isle Royale. The Marble Axe Co., of Gladstone, Mich., presented the party with a set of useful camp articles. In addition to the services of the volunteer members of the party and those just mentioned many others have aided in various ways. In behalf of the Museum I wish to express my sincere appreciation for this coöperation.

The field party was in charge of N. A. Wood, the Museum taxidermist. He was assisted by A. G. Ruthven, who had charge of the scientific work, and who directed it along lines outlined by the writer. The other members of the party were Messrs. Otto McCreary, N. F. Macduff, Max M. Peet and W. A. Maclean. All members of the party, except the leader, were volunteers, and thus their contribution to the success of the expedition was of a very substantial nature. Without their aid nothing could have been accomplished. Upon Messrs. Wood and Ruthven fell the responsibility of the party in the field, and to their care and foresight is due, in a large measure, the success of the expedition.

The field party left Ann Arbor, July 11, after three weeks of unfortunate and unavoidable delay, and explored the Porcupine Mountains until August 13. These mountains rise rather abruptly from the south shore of Lake Superior, and in a succession of ridges reach the height of about 1400 feet, at about two miles in the interior. The entire region is inhabited only by scattered trappers, and the forests are practically in their original condition.

From the Porcupines (August 13), the party went to Isle Royale, about 60 miles northwest of Houghton, where they made a hasty examination of the lower end of the island, the party remaining here until September 5. The lateness of the season furnished an excellent opportunity to make observations on the fall migration of the birds, and these notes are of peculiar interest on account of the insular location.

After the return of the party from the field, the preparation of the report was begun at once and has been carried on as rapidly as circumstances would permit. As the volunteer members of the party have been busy with other duties the preparation of the reports, in some cases, represents considerable sacrifice on their part. In particular this has been the case with Mr. Ruthven, upon whom naturally fell the heaviest burden.

A very pleasant feature in connection with the preparation of this report has been the generous coöperation of a large number of naturalists. In behalf of the University Museum I wish to acknowledge our indebtedness to these persons, who have, in addition to furnishing information concerning the collections, and the determination of specimens, in some cases contributed papers. The following list will show by whom the specimens have been determined.

Prof. Bruce Fink, Iowa College, Grinnell, Iowa. Lichens.
Dr. C. A. Davis, University of Michigan. Higher plants.
Mr. S. Alexander, Ann Arbor, Mich. Higher plants.
Dr. J. P. Moore, University of Pennsylvania, Philadelphia. Leeches.
Mr. Nathan Banks, U. S. Dept. of Agriculture, Washington. Spiders.
Mr. E. B. Williamson, Bluffton, Ind. Odonata.
Mr. J. R. De la Torre Bueno, New York. Hemiptera.
Mr. A. P. Morse, Wellesley College, Wellesley, Mass. Orthoptera.
Prof. A. J. Snyder, Springfield, Idaho. Lepidoptera.
Dr. W. M. Wheeler, American Museum Natural History, N. Y. Ants.
Mr. Bryant Walker, Detroit, Mich. Molluscs.
Dr. S. E. Meek, Field Columbian Museum, Chicago. Fish.
Dr. L. Stejneger, Smithsonian Institution, Washington. Amphibia.
Mr. Robert Ridgway, Smithsonian Institution, Washington. Birds.
Mr. H. C. Oberholser, Smithsonian Institution, Washington. Birds.
Dr. C. Hart Merriam, Biological Survey, U. S. Dept. Agriculture, Washington. Mammals.
Mr. W. H. Osgood, Biological Survey, U. S. Dept. Agriculture, Washington. Mammals.
Dr. Glover M. Allen, Boston Soc. Nat. History, Boston. Mammals.

This is also an appropriate place to express our obligations to Dr. A. C. Lane, State Geologist of Michigan, who furnished the party with maps and other information on Isle Royale and the Porcupine Mountains.

We are indebted to Mr. John F. Nellist for the contour map showing the location of the stations in the Porcupine Mountains, which he adapted *from* the map furnished by Dr. Lane.

A few remarks concerning the character of the field work, upon which the ecological reports have been based, will be of interest and also indicate the general bearing of such work. The aim of the present expedition was not directed primarily along the lines usually followed by natural history surveys. The aim was to secure *ecological facts and relations* concerning the plants and animals of the regions visited. In order to accomplish this, it was necessary not only to collect specimens but also to make observations concerning the relation of plants and animals to their environment. Mr. Ruthven was therefore instructed to run lines of survey across the region examined, in such a way as to include examples of all of the representative habitats or environments. These habitats were then to be examined in as much detail as time permitted. There is nothing unique in this method of selecting special localities, but in the detailed study of these various habitats special attention was given to the *relations of the biota* to its environment.* In this study attention was directed particularly to the forces and conditions composing the environment, in order that the dominant forces might be clearly recognized. This involved a careful analysis of the conditions, as it is only by such means that the laws of change can be recognized, and the dynamics of the habitat be understood. In this way, the habitat can be studied from the standpoint of *processes* rather than from that of the end result or effects of such forces, for it is very evident that if the habitats are to be understood it must be by a study of their laws of change.

Somewhat similar methods have been applied to special problems by a few plant ecologists, notably Cowles and his students, from whom many suggestions have been received, but such methods have not been applied to the study of both the plants and animals, and their interrelations, for any region. In the detailed application of this standpoint to the study of habitats, with its method of description in terms of *processes*, this report (Ruthven's section) is believed to be unique. That the ideal of interpretation, dynamically considered, has not been realized in the present ecological studies, will not be surprising to any one who understands the dynamic relations of ideals, or to one who has ever tried to depart from the customary static methods of working in order to think in terms of processes—dynamically.

As this method of thinking is not generally understood, it is occasionally applied in such a crude and general sense that its bearing can not be grasped when applied to special or concrete problems. There can be no question as to the general validity of this method, but what is now needed is to know how these processes are combined and related to produce particular environmental conditions or situations. It seems a very simple matter to give assent to the idea of the law of change, yet in its practical application this simplicity often vanishes at once when it is seen that it involves the relation of cause and effect. The organic environment is very complex and the ecologist, like the geologist has very frequently to deal with a complex of causes. But to be able even to refer a change to such a complex is often a distinct advance, as this involves a recognition of a problem requiring analysis, which is a further advance.

That these difficulties are not confined to the ecologist alone, but are obstacles which arise in any attempt as scientific interpretation, is worthy of special notice. We are thus able to see why certain naturalists apparently not recognizing or understanding the developmental processes which scientific ideas undergo, nor being acquainted with the tendencies of interpretation, dynamically considered, now making such rapid headway in ecological

*Biota—"the total of animal or plant life of a given region or period." Steineger.

botany, geography, physiography, geology and psychology, are inclined to look upon such attempts in biology as merely a fad or a personal peculiarity of the student, and not of any particular consequence. Such ideas confuse the incidental with the essential and suggest a complete failure to grasp the situation or to realize the fundamental importance of stating explanations in terms of processes.

Furthermore, in several of the allied sciences, the methods of dynamical interpretation have already made considerable advance. Here then is a resource, at present largely unworked by many biologists, where a wealth of ideas and explanations lie strewn over the surface and only need to be picked up in order to be utilized by those acquainted with this method of interpretation. It is thus very apparent that as soon as ecological phenomena are investigated dynamically and expressed in terms of processes, this science will of necessity become more closely correlated with those allied sciences which have already availed themselves of such methods.

If the signs of the times are now read correctly, the most striking advance in scientific methods of thinking during the present century will be in the direction of interpretation from the standpoint of processes—dynamically.

April, 1905.

CHARLES C. ADAMS,
Curator.
University Museum,
University of Michigan.

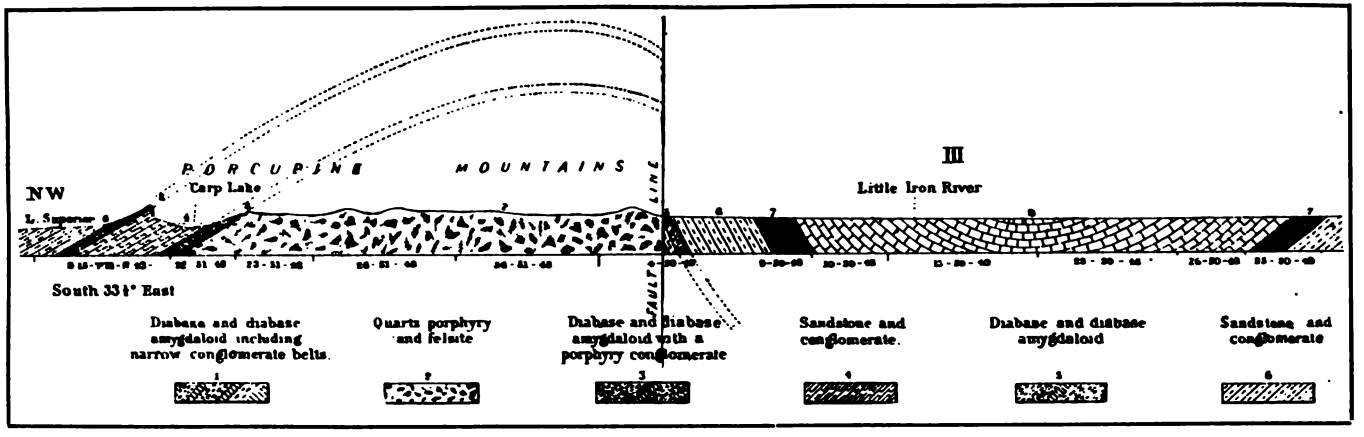

FIG. 2. Geological sections illustrating the structure of the Porcupine Mountains. (After Irving).

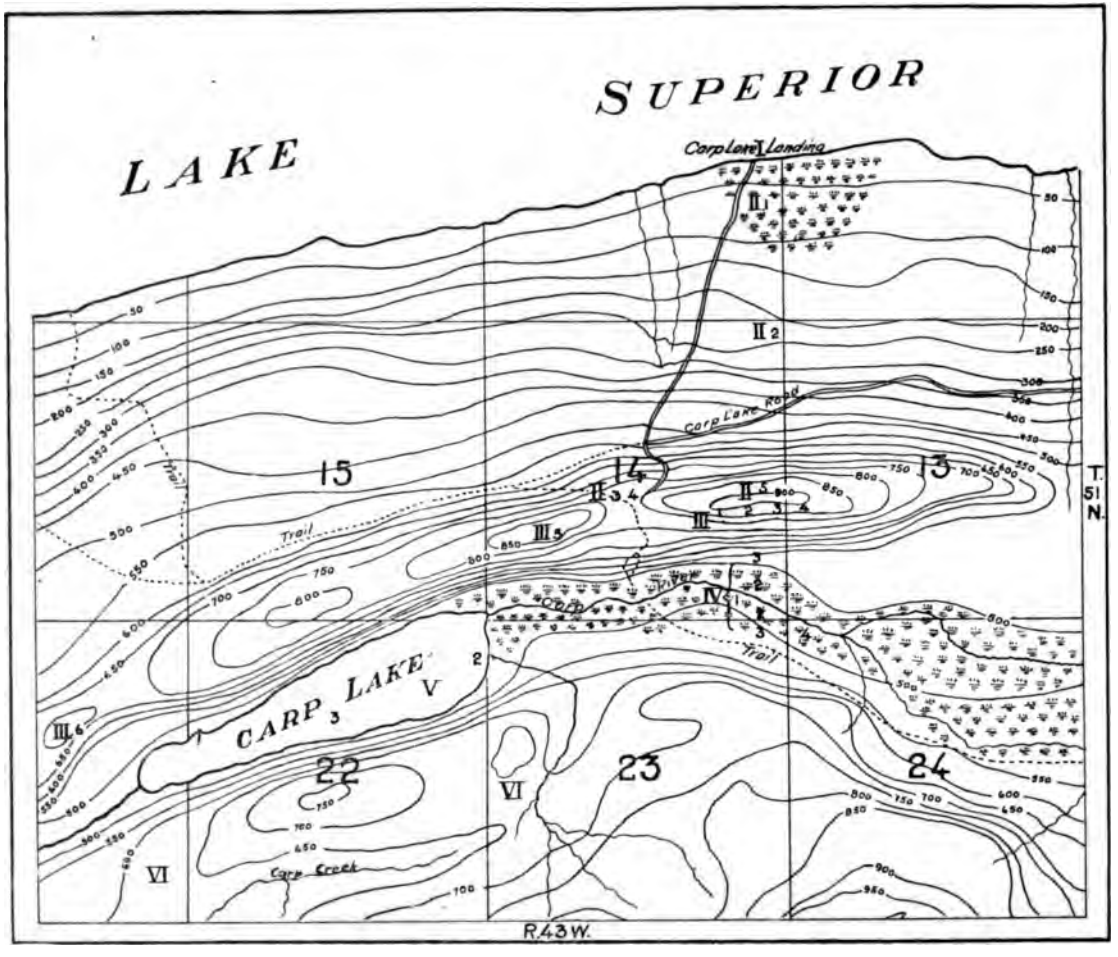

FIG. 3. Portion of the Porcupine Mountains showing location of field stations. Contour interval 50 feet. Altitudes above the level of Lake Superior, 601.19 feet.

AN ECOLOGICAL SURVEY IN THE PORCUPINE MOUNTAINS AND ISLE ROYALE, MICHIGAN.

A. G. RUTHVEN.

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1. History.
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INTRODUCTION.

The following report is based upon the results of the University of Michigan Museum Expedition to the Northern Peninsula of Michigan. The field work covered a period from July 13 to September 5, 1904. From July 13 to August 13 was spent in the Porcupine Mountains; the remainder of the time on Isle Royale. After a short reconnaisance, a line was run through that part of the region presenting the greatest variety of habitats, and stations were established on this line at which collecting was done. This plan greatly aided keeping in mind the relation between the physical conditions and the biota, as topographic and vegetational features were made the basis for the location of stations. It also made it possible to examine a great variety of conditions and thus obtain representative collections.

There were six men in the party: Messrs N. A. Wood, Max M. Peet, N. F. Macduff, Otto McCreary, W. A. Maclean, and the writer. Having had some experience in this work, Mr. Macduff assisted the writer in running the line, and while doing this listed the flora of the stations as they were established. Mr. Wood's time was mostly spent in caring for the bird and mammal skins, and in this work he was assisted by Mr. Peet, who, in turn assisted by Mr. Wood did the trapping. Mr. Peet also spent some time

collecting birds. Mr. McCreary devoted his time to the study of the habitats of the birds and to the collecting of ants, and Mr. Maclean to collecting vertebrates alone. The invertebrates and cold blooded vertebrates were collected by the writer, with the assistance of the other members of the party.

Except in the case of the molluscs and birds, no attempt was made to make exhaustive lists of the different groups, owing to the lack of time. The collections include principally the representative forms in the different habitats, as is indicated in the description of the stations and in the annotated lists.

While running the line of survey and establishing the stations, the dependence of the biota on the environmental conditions, and the adjustment between these conditions and the plant and animal societies was given special attention. Much light was thrown on the interpretation of these interrelations by considering the physiography in its dynamic or unstable aspect. The physiography is the resultant of the geological formations and the agencies constantly at work modifying them. Since the biota is dependent on the physical conditions in the different habitats, it is also unstable. A knowledge of the present and past conditions, which can only be obtained through a knowledge of the processes involved, is therefore necessary to explain the origin and distribution of the life of this region.

Both of the localities worked are favorable for study from the ecological standpoint, for the primitive and natural order of life prevails practically free from the disturbing influences of man. The forests have not been lumbered, and, although mining has been done both in the Porcupines and on Isle Royale, the workings were all early abandoned, and the conditions of nature have reverted so nearly to their primitive order that the only evidences now remaining are caved-in shafts, and occasional growths of aspen and birch which mark the site of old clearings. The whole region is wilderness and practically uninhabited. For this reason, field headquarters were established in order to have a suitable place where provisions could be stored, and where the specimens could be properly cared for. Owing to the nature of the woods, travel was arduous and all extended trips had to be made with packs, making it difficult to care for specimens more than two days' journey from camp. This difficulty, in the Porcupine Mountains, was counterbalanced by the rough nature of the topography that made it possible to get a large variety of habitats within a comparatively small area. The territory covered by the survey was, therefore, limited to about twelve square miles, in order that representative habitats might be worked in some detail. On Isle Royale, the low relief made it necessary to extend the line much farther in order to get a variety of habitats. It was, for this reason, impossible to cover the ground in as much detail.

It is well at this time to acknowledge our indebtedness to Mr. David Allie, caretaker of the Carp Lake Mining Property in the Porcupine Mountains, who placed at our disposal a large double shack furnished with bunks, stove and dishes, and aided us in many other ways. We are also indebted to Mr. Charles Preulx and Michael Hollinger, caretakers of the grounds of the Washington Club, Isle Royale, who also assisted us in many ways.

PART I. PORCUPINE MOUNTAINS.

1. HISTORY.

The Porcupine Mountains are situated in the Northern Peninsula of Michigan, in Ontonagon County, near the west end of Lake Superior, between the Iron and Presque Isle rivers. They were acquired by the United States Government from the Mississippi and Lake Superior Chippewa Indians by virtue of a treaty concluded October 4, 1842. The territory included in this treaty was bounded on the north by Lake Superior; on the east by the Chocolate river; on the south by the Michigan-Wisconsin boundary line, and on the west by the Montreal river. Isle Royale was also included.

Shortly after the treaty was concluded, prospecting was begun, and during the period that followed the speculative fever ran high. The mere presence of trap rock was taken as an indication of the presence of valuable lodes of copper, and all the trap in the Porcupine Mountain region was soon secured by permits. Many shafts were sunk, especially in the first range where the junction of the trap and sandstone outcrops on the face of a cliff. It was soon found, however, that in this region there are no well defined lodes, the copper being scattered promiscuously in irregular seams through the trap. Before the expiration of the year 1848, according to Foster and Whitney ('49–'50, p. 80), nearly all of the companies had abandoned their locations, and there was scarcely a white man left in the region.

The workings, with the exception of three or four, were little more than prospect holes, and the impressions left upon the country by the presence of man have nearly all been obliterated. In this condition, the mountains have remained for fifty years. All about them the adjacent country has been lumbered, but, owing to the fact that the pines do not occur in extensive tracts, that the streams are not suitable for logging, and that up to a few years ago it was not thought worth while to lumber hardwoods and hemlock, the forests have thus far escaped destruction. With the exhaustion of the pine in Michigan, however, and the consequently increasing price of lumber, it has become profitable to lumber this timber, and the forests are being rapidly taken off of the Northern Peninsula. The lumbering about Ontonagon has nearly reached the great belt of hemlock on the east and north slopes of the first range. The extensive possessions of the mining companies will protect these forests for a time, but, with the increasing demand for lumber, it will be but a few years until these magnificant forests will be destroyed.

2. GEOLOGY.

It is not the purpose of this report to go into detailed discussion of the geology of the region in question. It is necessary, however, to have a general idea of the geological structure in order to understand the topography, for the topography is largely due to the different degrees of resistance offered by the outcropping rocks to erosion. The structural geology of this part of Michigan has been worked out in detail by several geologists, most notably

by Irving ('83), but little attempt has been made to correlate it with the topography, in which connection it chiefly concerns the distribution of animals and plants.

The rocks of this part of the Northern Peninsula belong to what is known as the Keweenawan Series, and may in a rough way be divided into three classes,—the basic or trap rocks, the porphyries or acid rocks, and the detrital rocks.

The basic rocks make up the greater part of the whole series. They are finely crystalline rocks formed by the slow cooling of molten lavas containing 45 per cent to 50 per cent of silica, and consist of a lower compact portion grading upward into a vesicular or amygdaloidal portion interstratified with bands of unaltered red sandstone and conglomerate which become more numerous near the top. These basic rocks are true eruptives and constitute successive lava overflows from fissure eruptions (Irving, '83, p. 139).

The acid rocks occur between layers of basic rocks and are in part, like the basic rocks, true eruptives. They are composed of materials which fuse with difficulty, owing to the presence of silica, and which consequently cool rapidly into rocks composed of large crystals embedded in a glassy or porcelain like matrix.

The detrital members of the series consist of sandstones, conglomerates and shales formed from acid, or less prominently basic, rocks.

The Keweenawan Series is divided by Irving into two divisions, the Upper and Lower Keweenawan. The Upper Division consists wholly of detrital material, while the Lower consists of alternating flows of lavas and sediments. Most of the Upper Division lies under Lake Superior, but it also underlies the broad plain between Portage Lake and the Porcupine Mountains. This plain is interrupted by the Porcupine Mountains but continues again to the south.

The Keweenawan rocks border nearly the entire area of the Lake Superior basin. Besides forming the larger part of Keweenaw Point and constituting the Michigan shore to the Montreal river, they occur in northern Wisconsin, eastern and northeastern Minnesota and occupy a great area about Lake Nipigon. The outcropping trap rocks in Michigan occur as a range extending from the end of Keweenaw Point southwestward into Wisconsin. From this range the detrital sandstones and conglomerates dip away toward the lake. In the vicinity of the Porcupine Mountains, an outcrop of trap, owing to a fold, leaves the main range and swings away toward the lake, in T. 50 N., R. 44 W., and returning joins the main range in T. 49 N., R. 45 W.; within this fold occur the rugged ranges of the Porcupine Mountains.

3. GENERAL TOPOGRAPHY.

The mountains rise from the south shore of Lake Superior, Fig. 1, in Township 51 North, Ranges 42, and 44 West, as a convex ridge parallel to the lake shore. Back of this ridge they extend to the south as steep ridges and knobs in T. 50 N., Rs. 42, 43, 44 and 45 W., and T. 49 N. Rs. 43, 44, and 45 W. The whole system comprises three fairly distinct parallel ridges that nowhere attain an alpine height; the highest point, according to the charts of the United States Lake Survey, being 1421 feet above the level of Lake Superior or 2022.19 feet above sea level. Unfortunately the territory covered by the topographic map of the Michigan Geological Survey does not embrace this section, so this record has not been verified. The altitudes

FIG. 4. General character of the rock beach, breaker line near shore, station I.

FIG. 5. Wave action on the Lower Beach, station I.

referred to in this report are, unless otherwise specified, above the level of Lake Superior. The elevation above sea level may be obtained by adding 601.19 feet to the given altitude (Wright, '05, p. 36).

The first ridge, rising from the shore of Lake Superior, reaches a height of 850 to 900 feet within a mile and a half. It then decends abruptly 400 feet into the valley of Carp river. This cliff consists of about 200 feet of vertical face, with a steep bare talus slope at the bottom which is composed of angular fragments of trap and sandstone rock weathered from the cliff above. As may be seen from the contour map, this talus slope grades down into the flood-plain of Carp river, except on Sections 21 and 22, T. 51 N., R. 43 W.; here the river widens out to form Carp lake and the talus decends into the lake. This great cliff extends nearly continuously across T. 51 N., R. 43 W., a distance of over six miles. Beyond Carp river the mountains rise in steep ridges and knobs, but with no precipitous cliffs, to the valley of the Little Carp river.

About three miles south of the west end of Carp Lake, on T. 50 N., R. 44 W., Section 2, Little Carp river widens out to form Little Carp Lake. This lake, which marks the end of the line of survey, is about half a mile long and a quarter of a mile in width, with very irregular shores formed by the surrounding hills.

The mountains are most easily reached from Ontonagon, Michigan. From here to Union Bay, there is a good but sandy road. After leaving Union Bay the road enters the mountains and runs along the north slope of the first ridge. This slope is terraced by old beaches which mark higher levels of Lake Superior, and the road ascends the mountains by these natural driveways, ascending from one beach to another in the less difficult places.

It is important to bear in mind that the present topography is not in a static condition but is being constantly changed by the forces acting upon it, and that it will continue to be changed and modified until the land has been reduced to base-level. It must also be borne in mind that forms of life are dependent on the environments formed by the physical conditions. These facts are as important from the ecological as from the physiographic standpoint, for with changes in the physical conditions there are associated changes in the dependent habitats. The present conditions are not sufficient, therefore, to explain the distribution of the present biota, and the past conditions can only be understood through a knowledge of the action of present forces in producing changes in the environments. It is for this reason that the present geological and topographical conditions have been considered.

4. LOCATION OF THE FIELD STATIONS.

The line of survey began at Lake Superior on the north and south line of Sections 11 and 12, Township 51 North, Range 43 West, and from here ran southwest up the north slope of the first range to a saddle in the crest at an elevation of 750 feet on Section 14. From this point a transverse line was run along the top of the range, to the west on Sections 14, 15, and 21, and to the east on Sections 14 and 13. From the saddle on Section 14, the main line was continued due south down the escarpment on the south side of the range, across the valley of Carp river to the east and west line of Sections 14 and 23. From this point it was run southwestward across the intervening ranges to the top of Government Peak on Section 27. Another line was run down the valley of Carp river from the north and south line of Sections 24 and 25 to the West end of Carp Lake on Section 21. Here it

turns to the south, crossing Sections 21 ,28, and 23, Township 51 North, Range 43 West, to Little Carp Lake on Section 2, Township 50 North, Range 44 West. It then turns to the east and follows the valley of Little Carp river about a mile and a half up stream. On these lines stations were established where different conditions prevailed. Their locations, Fig. 3, were as follows:

Station I. Beach of Lake Superior, Secs. 11 and 12, T. 51 N., R. 43 W.

Station II. North Slope of the First Range, Secs. 11, 12, 13, 14, 15, and 16, T. 51 N., R. 43 W.

- Sub. 1. Arbor Vitae Swamp at Foot of Slope, Secs. 11 and 12.
- Sub. 2. North Slope, Secs. 11, 12 and 14.
- Sub. 3. Clearing in the Saddle, Sec. 14.
- Sub. 4. Aspen Zone about Clearing, Sec. 14.
- Sub. 5. Aspen Zone at Top of Ridge bordering the Bare Mountain Top, Secs. 13, 14, 15, 21, T. 51 N., R. 43 W.

Station III. Top of the first Range and the Southern Escarpment Secs. 13, 14, 15 and 21, T. 51 N., R. 43 W.

- Sub. 1. West Slope of the Ridge on Secs. 13 and 14.
- Sub. 2. Bare Mountain Top, Secs. 13 and 14.
- Sub. 3. Zone of Pines crossing First Range, Secs. 13 and 14.
- Sub. 4. East Slope of the Ridge on Sec. 13.
- Sub. 5. Mountain Top on Secs. 14 and 15.
- Sub. 6. Mountain Top on Sec. 21.

Station IV. Carp River Valley on Secs. 13, 14, 23 and 24, T. 51 N., R. 43 W.

- Sub. 1. Carp River, Secs. 14 and 24.
- Sub. 2. Flood-plain, Sec. 14.
- Sub. 3. Valley Slopes, Secs. 14 and 23.
- Sub. 4. Peat Bog, Secs. 14, 23 and 24.

Station V. Carp Lake, Secs. 15, 21 and 22, T. 51 N., R. 43 W.

- Sub. 1. Beach at West End of Lake, Secs. 21 and 22.
- Sub. 2. Delta at East End of Lake, Sec. 22.
- Sub. 3. Carp Lake, Sec. 22.

Station VI. Mountains between the Carp and Little Carp Drainage Systems, Secs. 21, 22, 23, 27, 28, 33, and 34, T. 51 N., R. 43 W.

Station VII. Little Carp Drainage System, Sec. 2, T. 50 N., R. 44 W., and Sec. 34, T. 51 N., R. 43 W.

- Sub. 1. Little Carp Lake, Sec. 2, T. 50 N, R. 44 W.
- Sub. 2. Beaver Meadow along Little Carp River, Sec. 34, T. 51 N., R. 43 W.
- Sub. 3. Little Carp River, Sec. 34, T. 51 N., R. 43 W.

5. THE BIOTA CONSIDERED BY STATIONS.

Station I. The beach of Lake Superior at the point studied is composed of outcropping strata of sandstone tilted at a considerable angle, Fig. 4. The nature of this shore has an important effect on the conditions of the beach. The effect of the beating of the waves of a lake is to cut into the shore as a horizontal saw. If the strata of this shore were perpendicular, the material would fall away from the face of the cliff as it was undermined, and the cliff would be vertical. The strata are inclined, however, so that as the lower part of the shore is cut into, the rock is removed more slowly, in blocks determined by the joint and bedding planes, Fig. 4. The edges of the truncated

strata form the bottom of a wave cut terrace off shore and determine the breaker line, Fig. 7. The submerged edges of these strata continue to be worn off by the abrasion of the material carried by the undertow until the surface of the terrace is more or less uniform.

On account of the exposure and the difficulty of obtaining a foothold, the environmental conditions are very severe, and the biota is limited both in individuals and species. The beach has been divided by physiographers into three parts, the Upper, Middle, and Lower Beaches, according to the influence of the hydro-dynamic factors. These factors, as Cowles ('99, pp. 112-175, and '01, pp. 56-57) has shown, have an important influence upon the environment of plants, so that the beach may be divided into the same divisions for our present purpose.

The Lower Beach is that portion of the shore exposed to the action of the waves during the summer months. At the point studied, Station I, owing to the dip of the strata, the water deepens rapidly off shore, and the breaker line is brought near to the beach, the lower part of which is thus exposed to the full force of the waves, Fig. 5. Exposed as it is alternately to the pounding of the waves and dessication in the sun the conditions are so severe that very little life can exist. The only form that is found here is the snail *Limnaea decollata* that occurs occasionally behind projecting outcrops, where it is to some extent protected from the direct force of the waves. This snail seems to be adapted to habitats of this nature, for it was found elsewhere only in rapid water in the larger rivers (Ruthven, '04, p. 192).

The Middle Beach lies above the Lower Beach and differs from it in not being exposed to the summer waves. It is, however, exposed to the action of the waves during the early winter months, while during the latter part of the winter the ice is shoved upon it in great ridges. It is thus, only during the growing season free from those conditions which make the Lower Beach practically uninhabitated, but certain conditions still make the habitat unfavorrable. Owing to the difficulty in gaining and retaining a foothold, the vegetation consists principally of lichens, *Lecidea lactea* and *Parmelia conspersa*, that are not dependent upon the substratum for nourishment. Along the exposed edges of joint and bedding planes, where disintegration is more rapid, a slight soil accumulates, Fig. 6. These crevices, as may be seen from the photograph, are taken possession of by several of the higher plant forms, but, owing to the short period that this beach is not exposed to the pounding of the waves, only the hardier plants can obtain a foothold, such as the Beach Pea,* Silvery Cinquefoil, Goldenrod, Pale Spiked Lobelia, Harebell and a few grasses, Fig. 6.

The fauna, probably owing in part to the lack of food, is also limited. The insects are represented by the butterflies, *Argynnis atlantis, Phyciodes tharos, Grapta gracilis, Grapta progne, Basilarchia arthemis*, and *Colias philodice*, and the dragonflies, *Aeschna clepsydra* and *Sympetrum costiferum;* forms that also occur on the Upper Beach. The spiders are more characteristic; *Epeira trifolium* and *patagiata* and *Linyphia phrygiana* spin their webs behind the outcropping strata, while *Pardosa lapidicina* runs about over the rocks. The destruction of this rock beach will probably destroy the habitats of these spiders, especially of those that spin webs, as it would be impossible for them to attach their webs on a sandy beach. The butterflies on the other hand are dependent upon the flowering plants, which are essentially crevice forms, so that their habitats would be increased by the comminution of the beach.

*All plant names in this report follow Britton's *Manual of the Flora of the Northern States and Canada*. 1901.

There are numerous pools on this beach, Fig. 6, in the angular spaces formed by the removal, presumably by ice, of portions of rock between the joint planes. These pools are, as a rule, above the reach of the highest waves, so that during the summer they are not flooded by the cold water of the lake. Their temperature is thus higher than the lake water. In several readings taken August 6, 7 and 8, the temperature of the water in these pools varied from 60° F. to 68° which was 10° higher than the lake water as it broke on the lower beach. The vegetation in these pools is very scanty, consisting chiefly of Algae which line the sides. The small number of species is probably due to their isolation and shallowness (6 to 18 inches), and to their smooth sides which make it difficult for the plants to gain a foothold. The fauna is much better represented than the flora. Besides a number of minute forms such as Crustaceans, Hydra, etc., there are a number of the higher aquatic forms characteristic of quiet water habitats. The insects are represented by water-boatmen, water-striders, and caddis-fly larvae, and the snails by *Physa ancillaria*, *Limnaea desidiosa*, *Planorbis parvus* and occasionally, near the Lower Beach by *Limnaea decollata*. These forms are found in all of the larger pools with the exception of *Limnaea decollata* which only occurred in the lower pools that are occasionally flooded by the waves. When these pools are flooded by an exceptionally high wave, they are often temporarily united with the lake and with each other which suggests a way by which certain forms may migrate along a shore of this kind. With the destruction of this beach these pool habitats will be destroyed, as pools of this kind cannot exist on a sandy beach.

The Upper Beach is above the reach of both summer and winter waves, and the environmental conditions are consequently more favorable than those of the Lower and Middle Beaches. The principal factor that still makes the habitat an unfavorable one for plants is the poor foothold afforded by the substratum. The soil, however, increases in amount at the edges of the joint planes thus affording a foothold for small trees and shrubs, Fig. 6, and to this soil is added a small amount of humus formed by decaying logs and annuals. Owing to these conditions, the flora presents a curious assemblage of forms. It is composed of the forms of the Middle Beach, Goldenrod, Beach Pea, Vetchling, Lobelia, Hare-bells, etc.; the fern, *Polypodium vulgare;* the heaths represented by the Bearberry, Great Bilberry and Dwarf Huckleberry that constitute the next society, and a number of trees and shrubs such as the Arbor Vitae, Mountain Maple, Mountain Ash, Large-leaved and Quaking Aspens, Juneberry, Eastern Ninebark, Dwarf Cherry, Wild Raspberry and Canadian Buffalo-berry, that in this region form a transitional zone between exposed habitats and the mesophytic forest. The fauna of this beach is in many respects similar to the fauna of the Middle Beach from which it cannot be distinctly separated. The forms found here which are not, as a rule, found also on the Middle Beach are the grasshoppers *Camnula pellucida*, *Circotettix verruculatus*, *Melanoplus atlanis* and *Melanoplus femoratus*, and the Lake Superior Chipmunk. The grasshoppers, as a rule, remain closely within the limits of this beach, with the exception of the forms of *Melanoplus* which are occasionally found also on the Middle Beach. The chipmunks are also seldom observed far from the drift logs that characterize this habitat.

The beach as a whole is thus, in a general way, divided into three habitats by the dominance of different processes which bring about different enviromental conditions, but these divisions, as may be seen from the photographs, are not sharply defined. The Lower Beach in general possesses

FIG. 6. Showing nature of the rock pools, crevice vegetation and lichens (white patches) of the Middle Beach, and the stunted crevice vegetation of the Upper Beach, station I.

FIG. 7. General character of the rock beach, breaker line off shore, station I.

little life, but near the upper limit of summer wave action a few straggling annuals come in that characterize the Middle Beach above, while near the upper limit reached by the winter waves and ice a few perennials of the Upper Beach occur. The biotic tension lines between these divisions also undergo occasional fluctuations, since the position of the tension line between the Lower and Middle Beaches is determined by the severity of the summer storms, while between the Middle and Upper Beaches it is determined by the height of the winter waves and ice.

Owing to the action of the waves, the beach as a whole is retreating inland, but as it retreats a wave cut and wave deposited terrace is being formed, and this by shallowing the water carries the breaker line off shore and lessens the effect of the waves, as illustrated in Fig. 7. The conditions of the Lower and Middle Beaches thus become more favorable, resulting in a progessive downward movement of the biota of the Middle and Upper Beaches respectively that decidedly narrows the beach zones.

On the other hand, the sinking of the coast in this region counteracts, in places, the tendency of the submarine terraces to decrease the efficiency of the waves. The deepening of the water near shore caused by this sinking of the coast brings the breaker line nearer shore, thus increasing the efficiency of the waves to such an extent that the beach habitats are being forced back into the adjacent swamps.

Station II. Substation 1. Back of the beach, at the foot of the first range, there often extends for considerable distances a narrow belt of arbor vitae swamp. This swamp owes its origin, according to Wright ('05, p. 37), to the general sinking of the beach of Lake Superior referred to in the discussion of the previous station. Gilbert ('97) in a discussion of this problem states that a general canting or tilting of the Great Lake Basins toward the southwest is taking place, as is indicated by the inclination of the beach lines of post-glacial lakes and by the drowned mouths of the rivers along the coast. It is evident that the rivers of the Porcupine region are drowned, as they are widened near their mouths into broad estuaries with adjacent swamps, and evidence that the tilting of the lake basin that is causing this is going on at the present time may be found in the submergence of standing trees along the lake shore, and in the discrepancy in the length of the section lines between different surveys, (Wright, '05, p. 37).

This sinking of the coast makes the conditions of a narrow zone just back of the beach too wet for some of the mesophytic forest forms that occupy the higher parts of the ridge, but at the same time it makes the conditions favorable for some of the forms of the arbor vitae swamp, so that this area is inhabited by certain forms characteristic of each of these habitats. The tree cover consists principally of the Arbor Vitae, with considerable Balsam Fir and some White Spruce and Paper Birch; the soil cover is characterized by the Running Pine, *Lycopodium clavatum*, and occasional clumps of Blue Flag. The molluscan fauna is very poorly represented, and the only shells collected were a few specimens of *Punctum pygmaeum* and *Zonitoides milium*. A single spider was taken here, *Dolomedes tenebrosus*. The mammals are those of the forest, such as the Southern Varying Hare, Southeastern Red Squirrel, etc., with the exception of the Lake Superior Chipmunk which was occasionally seen near the beach.

If the coast continues to sink, this swamp will approach more closely the conditions of the swamps of the river valleys and will become occupied more exclusively by the biota of the ordinary arbor vitae swamp, while

at the same time it will tend to retreat before the beach and invade the areas at present occupied by the mesophytic forest of the north slope.

Station II. Substation 2. Above the arbor vitae swamp, the north slope of the first range rises steeply to the top of the ridge and is covered by a dense mesophytic forest. The angle of this slope and the fact that it is formed by dipping strata, makes the drainage so rapid that the soil on the upper part tends to be washed downward and to accumulate at the bottom. The humus formed by the fallen twigs and leaves of the forest prevents in part superficial wash, and most of the water, for this reason, is conducted away under ground. The ravines are thus small and the streams transient. The lower parts of the slope support a dense hemlock forest in which there is deep shade, Fig. 8. The tree cover of this part of the forest consists principally of Hemlock associated with the Balsam Fir, Ironwood, Yellow Birch, isolated White Pines and a few Sugar Maples. The undergrowth of Ground Hemlock and Maple is very scanty, and the humus is thus composed chiefly of leaves and twigs of the Hemlock with the exception of localized accumulations of deciduous leaves from the maple underbrush. The soil cover is also scattered and is composed of the Large-leaved Aster, Wild Sarsaparilla, Twinflower, Goldthread, Maidenhair Fern, Wild Spikenard, Rattlesnake Plantain, Dwarf Dogwood, *Clintonia borealis*, and *Lycopodium lucidulum* and *clavatum*.

The fauna of the hemlock forest is also rich in species. Besides many insects and other invertebrates, there are a number of birds and the toad (*Bufo americanus*). The mammals are represented by the Canadian Porcupine, Northern Virginia Deer, Northern Plains Skunk, Woodchuck, Southeastern Red and Northern Flying Squirrels, Northeastern Chipmunk, Star-nosed Mole, Large Bobtail Shrew, and the Northern and Woodland Jumping, Canadian White-footed and Red-backed Mice. Owing to the predominance of conifers, it is to be expected that few shells would occur in this forest, but the accumulated leaves of the maple underbrush counteract the unfavorable nature of the coniferous humus and support a somewhat scattered molluscan fauna composed of *Zonitoides milium*, *Vitrea ferrea*, *Euconulus fulvus*, *Punctum pygmaeum*, *Helicodiscus lineatus*, *Strobilops virgo*, *Zonitoides exigua*, *Sphyradium edentulum*, *Carychium exile*, and *Agriolimax campestris*.

On the upper parts of the slope, the soil becomes thinner, and there is a noticeable change in the character of the forest. It is still mesophytic, but the Hemlock, Balsam Fir, Ironwood and Yellow Birch give way to a forest composed of the Sugar Maple, Basswood, and Paper Birch, in which the Sugar Maple predominates. This transition is gradual and while near the top of the ridge the Ironwood and Yellow Birch are practically absent, the Hemlock and Balsam Fir may still persist. The undergrowth in this part of the forest is much better developed, Fig. 9, and consists principally of Maple, Basswood and Ground Hemlock. The ground is covered to a depth of several inches with leaves, and the soil cover, although better developed, is practically the same as in the hemlock forest except that the Large-leaved Aster, Indian Pipe and Goldthread seem to become replaced by *Cinna latifolia*, White-flowering Raspberry, Fly Honeysuckle and Brake.

The changes in the environmental conditions with which are associated the changes in the composition of the flora toward the top of the slope do not seem to influence the fauna to a marked extent. As the tree cover is principally affected, the most marked change in the fauna is seen in the case of the birds, which are more closely associated with this type of vegetation.

Another change is the occurrence, on the upper part of the slope, of the Red-bellied Snake, *Storeria occipitomaculata*, which prefers dry, rather open woods. With the coming in of the deciduous forest, the humus becomes composed of leaves, and with this change in the nature of the humus is associated an increase, at least in the number of individuals, of molluscs. When the fallen leaves are examined, they are found to be connected by a film of water. Among these leaves seemed to be the favorite habitat of all the snails collected in these woods. The forms collected are *Zonitoides exigua Zonitoides arborea, Vitrea ferrea, Euconulus chersinus polygyratus, Helicodiscus lineatus, Punctum pygmaeum, Cochlicopa lubrica morseana, Sphyradium edentulum, Pyramidula striatella catskillensis, Strobilops virgo, Polygyra albolabris, Vitrea indentata* and *multidentata.*

It has been suggested (Whitford, '01, p. 301) that the presence of isolated White Pines in the mesophytic forest indicates a former dominance of xerophytic forms. This at once suggests an explanation for the origin of the present biota that is in accordance with the observed facts. When the waters of the glacial lakes receded and left the mountains exposed to denudation, the wash on this slope must have been considerable. The vegetation that first gained a foothold was probably a society analogous to that on the Middle Beach at the present time. These forms would be followed, as the conditions became favorable, by the heath society of the Upper Beach. At the bottom of the slope where the soil was thicker and the superficial wash less, the heaths were probably soon succeeded by the conifers that usually follow the heaths in this region. With the accumulation of humus in the coniferous forest, the superficial wash would become less, while the soil formed on the higher parts of the ridge would be held in front of the forest, permitting the coniferous types to ascend the slope and restrict the area occupied by the heaths.

As the coniferous forest became well developed at the bottom of the slope, owing to the more favorable edaphic conditions brought about by the accumulation of humus, the pine seedlings which require considerable light would no longer be able to develop. The seedlings of the deciduous trees, Maple, Basswood, Hemlock, etc., which would find a favorable habitat in the increased shade and humus of this forest, would then invade the coniferous forest as underbrush, so that, as the pines died off, they would be replaced by the forms of the present forest.

The fauna of this slope would have a history similar in many respects to that of the flora. If the slope was first invaded by the heath plants, it was probably at the same time invaded by the fauna that is associated with this society; a relation which would also hold in the case of the succeeding societies.

The conditions to which the forms in the different societies are adapted, or the habitats, would thus tend to migrate up the slope from the point of invasion, and the mountain top would be the scene of the extinction of the pioneer societies, the last place where they would be found. Since the mountains were islands for some time after the retreat of the ice sheet, the level at which this invasion of life took place presents an interesting question. Evidently it must either have taken place above one of the old beach lines while the mountains were yet islands, or after they had been joined to the main land by the subsidence of the lake. In the latter case, the invasion would have come in near the base of the mountains, as they are entirely surrounded by a low plain, but in either case the succession of societies would have been much the same, with the exception that in the former

case the migration of the societies would also have taken place down the slope, following the receding lake beach.

Station II. Substations 3 and 4. These substations are located in an artificial clearing and will not be discussed. The species that occur here will be found in the annotated lists.

Station II. Substation 5; and Station III. The north slope of the first range rises directly to the top of the ridge at an elevation of about 900 feet. Over the crest there is a sharp descent of several rods to the brink of the precipitous escarpment that overlooks the valley of Carp river. Fig. 10.

The effect of the dynamics of the mountain top are very conspicuous. The exposed rock is unprotected from the forces which cause disintegration, for as fast as it is broken up the particles are washed away, and thus the first soil to accumulate is in the exposed edges of joint planes. The soil washed down the north slope on Section 21, Fig. 11, is checked and held in front of the forest, which advances as the soil becomes sufficient to support it. On Sections 13 and 14, Fig. 10, the forest has advanced to the crest so that no soil from the bald areas is washed down the north slope. The soil formed on the south side of these areas, meeting with no obstruction, is washed over the precipice and accumulates in a narrow strip along the top of the talus slope, while that which is washed laterally from the top into depressions in the crest is also checked to a certain extent by the encroaching forest. The concentration of water in these inequalities causes them to be deepened into ravines, situated at right angles to the crest, and much of the material derived in this way is carried over the cliff and deposited as alluvial cones on the talus slopes below; these alluvial cones join the ravines above forming broad saddles across the ridge, Fig. 10. The face of the cliff is also exposed to weathering agencies that tend to pry loose portions of the rock between the joint planes. The larger fragments fall to the bottom of the cliff and go bounding down the talus slope, often starting miniature landslides of the talus material. The slope thus lies at the angle of repose of the material and is very unstable, Fig. 17. As a rule, the larger the fragment the farther down the slope it will go before coming to rest, and the strip of fine material at the top of the slope, which was formed partly from the soil washed over the cliff from the bald areas above, receives constant additions from the fine material that is loosened from the cliff face. Toward the bottom of the slope, the conditions become more stable, and the talus blocks are being disintegrated and decomposed into a residual soil. The mountain top, cliff, and talus slope habitats thus offer virgin conditions for plant and animal societies, and it is in localities such as these that the pioneer societies are found.

If the results of the processes at work on this ridge be summarized, it is evident that they are tending to lower the ridge toward a base leveled plain, thus changing the present conditions toward those found on the lower parts of the north slope.

Station II. Substation 5; and Station III. Substations 1 and 4. The biota of the north slope of the first range, pushes through the saddles and down the alluvial cones on the south side and mingles with the biota of the forest in the valley of Carp River, Fig. 10. From the north side and the saddles it extends upward and surrounds on three sides the bare areas of the higher parts of the ridge, but, owing to the changed environmental conditions, it becomes modified in its composition near the crest. The Hemlock and Balsam Fir and finally the Sugar Maple become replaced by a zone of aspen and oak, consisting principally of the Quaking Aspen, Paper Birch, Red and

FIG. 8. Hemlock forest, showing dense shade and lack of undergrowth, station II, 2.

Burr Oaks, associated with the Mountain Maple, Large-toothed Aspen, Mountain Alder (*Alnus alnobetula*), several willows and scattered Red and White Pine. The underbrush and soil cover of this zone is composed of *Polypodium vulgare*, Juneberry, Scarlet Sumac, Bush Honeysuckle, Eastern Ninebark, Great Bilberry, Round Leaved Dogwood, Dwarf Cornel, Narrow-leaved Cow-wheat, Low Snowberry, *Polypodium vulgare*, and *Lycopodium clavatum, complanatum* and *selago*; *Linnaea americana* may also be mentioned.

Higher up the mountain the soil cover becomes replaced by the Bearberry, Dwarf and Low Black Blueberry, New Jersey Tea, and Creeping Wintergreen. The White Pines still persist, but the shrubs mostly disappear, and the oaks and aspens associated with *Juniperus nana* become very scrubby, often forming small mats on the slight soil, Fig. 12.

As in case of the vegetation, the range of many of the animals of the mesophytic forest reaches an upward limit in the aspen zone, where they occur mingled with other forms that replace them on the bald areas. Thus the molluscs become noticeably fewer in individuals in this zone; *Zonitoides exigua, Cochlicopa lubrica, Vitrea ferrea, Euconulus fulvus, Helicodiscus lineatus and Carychium exile* seem to drop out of the fauna entirely, while *Punctum pygmaeum, Sphyradium edentulum, Zonitoides milium* and *arborea*, and *Strobilops virgo*, by changing their habitats from the damp fallen leaves of the mesophytic forest to the dry soil held by the heaths, are able to persist. Mingled with these forms was found for the first time *Bifidaria curvidens*. Similarly the only grasshopper that occurs in the mesophytic forest (*Tettix*) is replaced in the aspen zone by *Melanoplus luridus, fermoratus* and *islandicus, Chloealtis abdominalis* and *conspersa*, and *Camnula pellucida*, while the Northeastern Chipmunk, Northern Plains Skunk, Woodchuck, and the woodpeckers, owls, chickadees, nuthatches, etc. are mostly replaced by the Lake Superior Chipmunk, Junco, Robin, and Bluebird. The smaller mammals such as the mice, moles and shrews seem to persist without noticeable diminution in abundance.

Station III. Substations 2, 5 and 6. On the mountain top beyond the limit of the aspens and oaks, the biota is composed almost exclusively of the forms that appear in the upper part of the aspen zone. The heaths, represented by the Bearberry and Creeping Wintergreen, with the Dwarf and Low Black Blueberry and New Jersey Tea, form a large dense mat beyond the aspen zone, that extends in long tongues along the crevices on the bare top, Fig. 11. On the denser portions of this mat occur widely scattered White and Red Pines with many dead stumps, Fig. 13.

On the bare mountain top, the flora consists only of the lichens, *Lecidea lactea, Lecanora conspersa* and *cinera, Parmelia conspersa*, and *Stereocaulon coralloides*, on the surface of the rock, and a crevice vegetation of Harebell, Three-toothed Cinquefoil, Wild Wormwood, Evening Primrose, *Panicum xanthophysum, Polypodium vulgare, Polystichium lonchitus, Asplenium trichomanes*, and *Solidago bicolor, lanceolata, juncea* and *erecta*.

The molluscs, *Punctum pygmaeum, Euconulus chersinus polygyratus, Zonitoides milium, Strobilops virgo, Vitrea indentata* and *Bifidaria curvidens*, that characterize the upper part of the aspen zone, also occur in the larger heath mats, associated with *Acanthinula harpa. Bifidaria curvidens* greatly predominates in this fauna. Dead specimens of *Helicodiscus lineatus* and *Succinea avara* are often found in the rock crevices near the brink of the cliff, but these were probably blown here as they could hardly exist in this habitat, being moisture loving forms. The characteristic insects of this station are the dragonfly, *Sympetrum obtrusum*, the butterflies, Argynnis cybele,

Thecla edwardsii, and the grasshoppers, *Chloealtis abdominalis* and *conspersa*, *Melanoplus fasciatus*, *amplectens* and *islandicus*, *Circotettix verruculatus*, and *Atlanticus pachymerus*.

The Cliff. Owing to the precipitous nature of the cliff, the rock fragments are removed as fast as they are split off the parent rock, and the environmental conditions of the cliff face remain uniformly severe. The only vegetation that can exist consists of the lichens, *Gyrophora* (*Umbilicaria*) *vellea*, *Amphiloma* (*Pannaria*) *languinosum*, and *Biatora lucida*, that manage to obtain a foothold on the face of the rock, but these are invariably destroyed as the rock weathers away. On the ledges, however, where the conditions are more permanent, a number of plant forms may gain a foothold, the extent of the vegetation depending upon the age and size of the ledge. On the fresher ledges the only plants are the lichens, among the representative forms of which may be mentioned *Stereocaulon coralloides*, *Parmelia conspersa* and *Lecidea lactea*. Where a slight soil has accumulated, the Harebell, *Panicum xanthophysum*, *Polystichium lonchitus*, Three-toothed Cinquefoil, and Goldenrods may occur. While on the larger ledges, which often possess several inches of soil, the Bearberry, New Jersey Tea and other forms of the heath society, together with the Juneberry, White and Red Pine, *Juniperus nana*, Arbor Vitae and Northern Poison Oak may obtain a foothold, Fig. 14.

The fauna of the cliff face is also very limited. The ledges are too small to support a characteristic fauna, but ants grasshoppers and dragon-flies are often found here. The butterfly, *Grapta gracilis*, was occasionally seen in considerable numbers on the cliff face, but the only animal that can be said to be characteristic of this habitat is the Raven which nested here.

Station III. Substation 3. Where the cliff is broken by large ledges, Fig. 15, the conditions are more stable, and the vegetation consists principally of a growth of Red and White Pine and an undergrowth of Reindeer Lichens and heath plants, that extends up the cliff and across the mountain top. Where these belts of pine join the mesophytic forests of the north slope and river valley, the undergrowth is predominated by the Sugar and Mountain Maples and Quaking Aspen. The fauna of these belts is peculiar. Although the Pine Warbler and Crossbills are often seen here, the belt is too small to support an extensive pine forest fauna, while at the same time it is, perhaps, the deposit of pine needles that excludes the molluscs of the mountain top and mesophytic forest.

Talus Slope. Where the precipice is not broken by large ledges, the fragments of rock that weather from its face fall to the talus slope below. The finer material collects along the top of the slope, at the foot of the cliff, and supports a vegetation composed of a number of species, Fig. 10. Among the more prominent of these are the Thorn Apple, Red Oak, Quaking Aspen, Wild Red Cherry, Round-leaved Dogwood, Juneberry, Bearberry, New Jersey Tea and scattered White and Red Pine. Below this zone the talus slope is strewn with dead wood and recently fallen trees, mostly pines, Fig. 16. Where the cliff is composed of trap, Substation 6, the blocks which fall from its face are large, and the talus slope is practically devoid of vegetation with the exception of scattered patches of lichens, principally *Parmelia conspersa*, Fig. 17. Where the cliff is composed of sandstone, the talus material is finer and often supports a scattered vegetation of White and Red Pine, Paper Birch, Wild Cherry, Northern Poison Oak, and Virginia Creeper. Toward the bottom of the slope, the first vegetation that occurs are the lichens, principally *Lecidea lactea* and *Parmelia conspersa*, the latter

predominating. These forms cover more or less completely the surface of the talus fragments. Farther down *Stereocaulon coralloides* and *Lecanora conspersa* are added to this society which is dominated on the lower part of the slopes by the Reindeer lichens, *Cladonia rangiferina* and *alpestris*, that often occur superimposed on the remains of the other lichens. These are replaced toward the bottom of the slope by the Bearberry, New Jersey Tea, *Polypodium vulgare*, Raspberry, Wild Red Cherry, Mountain Maple, Paper Birch, Quaking and Large-toothed Aspens, Beaked Hazelnut, Blackberry, Brake, and Bush Honeysuckle, that in turn give way to the typical mesophytic forest forms of the river bottom.

The environmental conditions as regards the fauna are more unfavorable than on the mountain top. The only forms that are found here are a few ants in the narrow zone of vegetation at the top, and occasional grasshoppers and dragon-flies on the bare slope below. Near the bottom of the slope the Lake Superior Chipmunk was often seen running about over the rocks and among the bushes that fringe the forest. Forms from the mesophytic forest of the river valley such as the Garter Snake and Northeastern Chipmunk are also occasionally seen here.

When the biota of the mountain top and north slope are listed by habitats, the genetic explanation suggested for the forest of the north slope is enforced. It is evident that certain groups of forms are, in a general way, dependent on certain environmental conditions. The action of the forces which bring about these conditions tend to modify those that exist at any one time, so that the biota must adjust itself to the new conditions or be exterminated. This is especially noticeable on an elevated area. It was shown in the discussion of the topography that the effect of physiographic processes on the ridge in question was to reduce it to a base-leveled plain. The environmental conditions are thus being changed and modified in the direction of the conditions that prevail on the lowland at the foot of the mountain. These conditions are brought about first on the lower parts of the ridge, so that the habitats of the lowland biota are extended at the expense of cliff habitats, and correlated with the changing conditions a succession of societies occurs. This may be easily seen from the top of the ridge, Fig. 11. The first plants to get a foothold on the bare rocks are those of the lichen society such as *Lecidea lactea* and *Parmelia conspersa*, that form large patches over the exposed rock surfaces. The wash and decay from these mats is at first mostly washed away down the slopes. As soon, however, as the processes of weathering have opened the edges of the joint planes, the soil accumulates in them and with it a small amount of organic material from the lichen mats. The conditions thus become favorable for a crevice vegetation consisting of certain mosses, the Harebell, Cinquefoils, Goldenrods and grasses. As the soil, held in the crevices by the plant roots, increases in amount, the conditions become still more favorable, and the crevices are invaded by the heaths from the extensive mat that surrounds the mountain top on three sides, in front of the mesophytic forest. The dense mats formed by the heaths do much to make the edaphic conditions more favorable by holding the soil as it is formed, checking that which is washed from higher areas, and by accumulating the humus formed by the decay of the vegetation.

The first society to gain a foothold on the lichen mat is represented by the White and Red Pines, and the next by the forms of the aspen zone. In many instances, the Quaking Aspen, which is one of the hardiest plants of this zone, follows the heaths along the crevices before the pines can obtain a foothold, but in any case the pine stage is but poorly represented, probably owing

The fate of the pines on the exposed top of this ridge, the scrubby nature of the aspens and oaks, and the fact that the tops of a large percentage of the living pines are dead, suggests that the timber lines on some mountains may be greatly influenced by wind.

Station IV. Substation 3. Beyond the limit of the falling rock fragments on the talus slope, where the rocks have been disintegrated and decomposed to form a soil, the Paper Birch, Mountain Maple, Aspen and Mountain Ash become mixed with the Sugar Maple, Balsam Fir and Basswood, that gradually predominate to the exclusion of the Aspen and Mountain Ash. In the forest near the bottom of the slope, Hemlock forms a part of the tree cover and occasionally predominates to such an extent that a hemlock forest results similar in composition to the hemlock forest at the foot of the north slope. More often, however, the Sugar Maple predominates in this forest, associated with the Balsam Fir, Basswood and Ironwood, with scattered Hemlocks, and White Pines, thus making it similar in composition to the mesophytic forest of the north slope with which it is connected through the saddles. The ground cover and fauna are also practically the same and need not be listed.

Station IV. Substation 2. Owing to the flat nature of its valley, Carp river above Carp Lake is a slow meandering stream that is doing practically no vertical cutting, Fig. 18. It is easily turned from side to side, and, as it is deflected toward one side of its valley, it tends to cut into it, while on the other side of the bend, owing to the decrease in the velocity of the current, part of the load is deposited to form mud flats. The river thus tends to broaden its valley at the expense of the neighboring divides and to build up its flood-plain with a part of the material derived in this way. The material that is not deposited on the mud flats is carried on until the stream reaches Carp Lake, where again owing to its diminished velocity, the stream deposits much of its load in the lake, forming a large delta at the mouth of the river. On the flood-plain of the river, Fig. 18, the deciduous forest either gives way to a coniferous society characterized by the Tamarack, Spruce, Arbor Vitae and Black and White Ash, which in turn grades toward the river into an extensive alder thicket, or, where the valley is narrow, the coniferous society may be nearly or entirely absent, and the hardwood forest grade directly into the shrub society. The shrub society is largely composed of the Hoary Alder (*Alnus incana*) associated with several willows, occasional Tamaracks, and scattered clumps of Red-osier Dogwood. The undergrowth in these thickets is not extensive; among the more noticeable forms are the Skunk Cabbage, Sensitive and Cinnamon Ferns, Skull Cap, and several species of violets.

The fauna is characterized by a great increase in the number of birds; the warblers and sparrows are especially conspicuous. This is also the habitat of the Red Backed Salamander (*Plethodon cinereus*) and the Wood Frog (*Rana sylvatica cantabrigensis*). For some undetermined reason, the molluscs seem to be very poorly represented in this society.

Between the alder thickets and the river, in the broader portions of the valley, there is often a well defined zone of vegetation characterized principally by the Dwarf Cassandra. Between the two societies the Hoary Alder and Dwarf Cassandra occur mingled with the Wax Myrtle, High Bush Blackberry, American Meadow Sweet, and Few Flowering Cranberry. Toward the river, the Hoary Alder, Willows, Red-osier Dogwood and Tamarack occur only in scattered clumps among the Cassandra that forms a low dense thicket. Less prominent but conspicuous forms in this society are the Pale

St. Johns Wort, Joe Pye Weed, Swamp Milk Weed, Running Swamp Blackberry, Marsh Cinquefoil, Ladies Tresses, Marsh Bell Flower, Creeping Snowberry, *Solidago uliginosa*, and a number of grasses and sedges among which are *Eriophorum cyperinum, Calamagrostis canadensis, Deschampsia flexusa, Panicularia canadensis, Scirpus cyperinus, Carex viridula, riparia*, and *filiformis*. Owing to the low height of these forms, the habitat is open, and the fauna is similar in many ways to the fauna of the mountain top, but, owing to its proximity to the river, several new forms are added. The more characteristic forms are the butterflies, *Argynnis cybele var.* (near *leto*), *Argynnis atlantis* and *Basilarchia arthemis;* the dragon flies, *Gomphus spicatus, Lestes unguiculatus, Calopteryx aequabilis* and *Sympetrum obtrusum*, and the grasshoppers, *Atlanticus pachymerus, Stenobothrus curtipennis, Podisma glacialis, Melanoplus islandicus* and *Scudderia pistillata*. It might be expected that this habitat would be favorable for reptiles and amphibians, but while it is the habitat of the Garter Snake, *Thamnophis sirtalis sirtalis*, the dense entangled nature of the vegetation apparently excludes the frogs.

The cassandra zone extends only to the river bank, where it generally mingles with a narrow zone of alders on the low natural levees, but a number of grasses and sedges, *Juncus effusus, Calamagrostis canadensis, Scirpus cyperinus, Dulichium arundinaceum, Carex filiformis, viridula* and *riparia*, push out on the mud flats to the edge of the water, Fig. 19, and form a transition society between the cassandra zone and the aquatic forms of the river.

The fauna of these flats is also transitional between the aquatic and terrestrial habitats. This is illustrated by the presence of the turtle, *Chrysemys marginata*, and the frogs, *Rana clamitans* and *septentrionalis*, which are amphibious and thus intermediate in habits between the two habitats. The birds are the waders and shore birds that find their food here; among these may be mentioned the sandpipers, snipes, herons, and bitterns. Although by no means limited to this habitat, and to be more properly listed with the fauna of the mesophytic forest, the Canadian Porcupine is a conspicuous form on these flats where it may often be seen, singly or in groups of two or three, feeding on the pads of the water lilies.

Owing to the steepness of the sides of the valley, the entire succession of societies is only found in the broader parts, for where the river swings toward the side of the valley the flood-plain is destroyed, and the cassandra, alder and coniferous societies are all limited to a single narrow zone between the river and the deciduous forest.

If the different flood-plain societies be compared with the succession of forms in a tamarack swamp as given by Transeau ('03, pp. 403-404), a remarkable similarity will be revealed. The societies that occur in the bogs of more southern localities are here spread out over the entire flood-plain of the river, and the tamarack swamps of Indiana, Illinois and southern Michigan are minature reproductions of the flood-plain conditions in this region.

Station IV. Substation 4. There are, however, areas where more typical bog conditions prevail, so that in the wider parts of the valley the bog types may attain a much better development. In these areas, the bog societies are not arranged in concentric zones, as in the southern bogs, but are, as the flood-plain societies, more or less parallel to the river. The succession is much the same as on the flood-plain and in the southern bogs. The sedge zone grades into a zone composed largely of Dwarf Cassandra associated with the Rose, Juneberry, High Bush Blackberry, Wax Myrtle, American Meadow Sweet, Swamp Honeysuckle, and Cranberry, that is in turn followed by a society composed largely of Balsam Fir, Tamarack and White Spruce,

FIG. 10. Escarpment of the First Range, looking west, showing the cliff and talus slope, station III. 5, and Carp Lake, station V, in the distance.

the under parts of which usually [illegible] Striped Shiner, Redfin Shiner, Strawberry Darter, Johnny Darter, Least Darter, and Mud Minnow in a third group of Sticklebacks and other minor species.

The forms of these groups are as follows: The minnows are represented by Notropis stramineus, Notropis heterodon, Notropis hudsonius, Notropis atherinoides, Notropis cornutus, Notropis whipplii, Notropis [illegible], Notropis [illegible], Notropis [illegible],

the under growth of which consists principally of Dwarf Cornel, Creeping Snowberry, Labrador Tea, Pitcher Plant and Gold Thread on a thick carpet of Sphagnum and other mosses.

The fauna of these bogs is not characteristic. The mammals are represented by Hoy's Shrew, Southeastern Red Squirrel and Red-backed Mouse, and the molluscs by *Zonitoides arborea, Zonitoides exigua, Pyramidula striatella catskillensis, Pyramidula asteriscus, Helicodiscus lineatus, Strobilops virgo, Punctum pygmaeum, Vitrea ferrea, Sphyradium edentulum,* and *Pallifera hemphilli*, all forms that are abundant in the deciduous forest.

That certain forms, for example the Pitcher Plant and Sphagnum, that characterize the southern tamarack swamps are also restricted to the same habitat in this region, and the fact that the climax flood-plain society is evidently of the deciduous forest type, suggests that the cassandra and coniferous societies will be ultimately replaced in the flood-plain succession. But, on the other hand, the wide distribution in this region of many of the forms that are largely confined to bogs further south, such as the Balsam Fir, Dwarf Cornel and Red-backed Mouse, Starnosed Mole, and Southern Varying Hare, indicate that the conditions which permit the boreal forms to hold certain swamps to the south are here more wide spread; while the similarity between the bog and flood-plain societies indicates, as might be expected, that the more nearly related habitats are the most noticeably and probably the first to be modified by the change of conditions.

Station IV. Substation 1. The amphibious forms of the mud flats grade into the aquatic forms of the river by such marginal forms as *Dulichium arundinaceum* and *Sagittaria.* The slow current of the river is an important factor in determining the nature of this habitat, as it results in conditions similar to those that prevail in ponds, thus permitting a biota adapted to pond conditions to gain a foothold. The vegetation, although poorly represented, is decidedly of the quiet water type, being composed principally of the Yellow Pond Lily, and *Myriophyllum*, and to a small extent of the Sweet Scented White Water Lily, and *Potamogeton natans*, Fig. 19.

The fauna also shows the effect of the slow current, but, owing to lack of data on the habitats of the different forms, it is impossible to determine definitely to what extent it is modified by the changing conditions. It is, however, evident in a general way, for the forms that occur here are all forms that occur in ponds as well as streams, while the characteristic river forms that occur in the streams after they leave the mountains are apparently not represented. For example, the molluscs found here, *Amnicola limosa, Ancylus parallelus, Valvata tricarinata, Physa sp.* and *Planorbis exacuous, hirsutus* and *campanulatus*, were all found on the vegetation and are forms that, according to Baker, inhabit ponds and streams with aquatic vegetation and mud bottom, but *Limnaea decollata*, that occurs on the bare rocky bottom in the swift waters of the lower parts of the river, is apparently absent. The fish are represented by the Fine Scaled Sucker, Horned Dace, Spawn Eater, Trout Perch, Yellow Perch, and *Nototropis cayuga.* The Horned Dace is, according to Forbes, almost entirely confined to brooks and small streams. It is very abundant in Carp river, especially in the head waters, and may thus be taken to represent the stream conditions that still prevail, but in the quiet waters near the lake, there are associated with it the deeper, quiet water, bottom feeders, the Yellow Perch and Sucker, while the characteristic stream forms such as the Brook Trout and Grayling were not found. Certain other forms are so closely associated with this habitat that they must be listed here; the more conspicuous of these are the dragon flies,

Calopteryx aequabilis, Aeschna clepsydra and *Plathemis lydia*, and the Kingfisher, Muskrat, etc.

Station V. Substation 3. The biota of Carp Lake indicates that the environmental conditions are very similar to those that exist in the river above it but are even more pond-like. The fish are the same with the exception of the Horned Dace, which was not found here. The Sucker and Yellow Perch seem to predominate. Toward the shore the bottom becomes covered with vegetation, chiefly *Myriophyllum*, among the leaves of which, especially in the axils, occur the snails, *Amnicola limosa* and *Valvata tricarinata*. This society soon becomes mixed with *Potamogeton natans* that forms a large well defined zone. On the inner margin of this zone, the Tape Grass, *Vallisneria spiralis*, often occurs in extensive mats but does not form a definite zone. The next zone of importance is composed largely of the Yellow Pond Lily that is replaced near shore by the Canada Rush, *Juncus canadensis*, that becomes largely mixed in shallow water with the Scouring Rush, *Equisetum fluviatile*.

Station V. Substation 1. Where this marginal rush zone extends to the shore, the bivalves, *Sphaerium simile, Anodonta marginata*, and *Pisidium sp.*, and the univalves, *Planorbis bicarinatus, campanulatus* and *deflectus* are found in the silt and on the small stones.

On the fine sand of the narrow beach, *Equisetum hyemale* associated with the Horned Bladderwort (*Utricularia cornuta*), Nodding Ladies Tresses, and Seven Angled Pipewort forms a scattered vegetation behind which comes an alder thicket which is followed in turn by the mesophytic forest types.

Station V. Substation 2. The delta that is being formed by the river at the east end of the lake is similar in many ways to the mud flats along the river and presents similar but more extensive environmental conditions. On the submerged part of the delta, *Juncus canadensis* is mostly absent from the rush society which is extensive and composed principally of *Equisetum fluviatile* associated on the inner margin with *E. hyemale* and *littorale*. These forms are replaced on the area that is ordinarily unsubmerged, by *Dulichium arundinaceum, Carex filiformis, riparia* and *viridula*, associated on the dryer areas with *Calamagrostis canadensis, Scirpus cyperinus, Agrostis hyemalis, Eupatorium purpureum. Deschampsia flexusa, Panicularia canadensis, Solidago uliginosa*, Swamp Milkweed, Nodding Ladies Tresses, Pale St. Johnswort and Marsh Cinquefoil.

The fauna also shows the similarity between the conditions of this habitat and the mud flats. The dragon flies found here are *Enallagma hageni, Nehalennia irene, Enallagma carunculatum, Ischnura verticalis, Hagenius brevistylus, Gomphus spicatus, Aeschna clepsydra* and *Plathemis lydia* Of these *Enallagma hageni* is the characteristic form and occurs in considerable numbers. The birds, as on the mud flats, are the waders and shore forms such as the Carolina Rail, Great Blue Heron, American Bittern, Solitary Sandpiper and Wilson's Snipe. The nature of the habitat is also shown by the presence of most of the amphibian species of the region. The frogs are represented by *Rana pipiens brachycephala, clamitans*, and *septentrionalis*. No turtles were observed, but the Garter Snake, *T. sirtalis sirtalis* was taken several times.

The grass and sedge society passes directly into an alder society without an intervening cassandra zone, and the forms of the alder society are in turn followed by the forms of the deciduous forest.

It was shown in the discussion of the topography that the tendency of an

FIG. 11. "Bald" on the top of the First Range, station III. 6, showing the bare rock, heath plants in crevices, scattered pines and stunted aspens that characterize this habitat.

FIG. 12. The zone of stunted aspens, station II. 5, surrounding the "bald." The pine stumps show the effect of the wind.

agraded stream is to cut into the sides of its valley, and to build up a plain at its own level by the deposition in its channel of the material derived in this way. It was also pointed out that areas representing different stages in this process are characterized by different biota. Since the process is still going on it is necessary to consider the biota in reference to the changing conditions. The nature of the changes which Carp river produces on the topography is determined by its low gradient and slow current. As it meanders over its flood-plain, the mud flats that are formed on the inner side of the bends are extended into the stream by the deposition of material on their inner margin. The quiet water and favorable substratum on the submerged parts of these flats afford a favorable habitat for the pond or quiet water forms of life. As the deposition of the streams during floods builds these flats above the ordinary level of the river, the conditions become unfavorable for the aquatic forms, which are compelled to migrate outward; at the same time, however, they become favorable for the amphibious forms of the grass and sedge zone that gradually push out and occupy the flat as it becomes dry enough. The continued deposition during floods, and the accumulation of plant remains continue to raise the level of the mud flats, and, as the conditions become dryer, they support successively the cassandra, alder and the deciduous forest types of life. Where the river cuts into the sides of the valley, the flood-plain is destroyed, and its societies are limited to a single narrow zone between the deciduous forest and the river; in this zone, the littoral, cassandra and coniferous societies may be entirely lacking, but the alder society is nearly always represented.

Carp Lake may be considered as the river expanded and covering its flood-plain to the sides of the valley, and the changes that are going on are very similar to those that are being produced by the river. The conditions however, are more pond-like for the current that the river possessed above the lake is lost, so that there is no lateral corrasion. Deposition is going on all about the margin, owing to wash from the sides of the valley and the deposits made at the mouth of the river, so that the aquatic conditions are being changed into the terrestrial in a manner analagous to the development of a mud flat into a flood-plain, and the successive zones referred to in the discussion of the biota are steadily encroaching on the lake.

Different stages in the destruction of the lake may be observed nearly every where about its shores, but, owing to the dominance of different factors, the encroaching societies are not always equally developed. The extreme of this is shown on the north shore where, owing to the proximity of the cliff, the talus slope dips into the lake, the fresh talus fragments fall nearly to the water and very little soil has accumulated. There is, therefore, no shelving beach at this point, the aquatic and mud flat societies are absent while the alder zone is represented only by a few forms, the Hoary Alder more conspicuously, and is largely mixed with the Mountain Ash, White and Red Pine and Wild Cherry of the talus slope. At the east end of the lake the grass and sedge zone constitutes the principal society, for, owing to the large amount of material carried by the river, the delta is built up to the level of the lake much faster than it can be raised above it by the accumulation of plant remains and flood deposits, while at the same time owing to the shelving nature of its outer margin, the aquatic zone is also extensively developed. At the west end of the lake, however, the margin is shallow, deposition is slow, and the aquatic societies are the most prominently developed.

But, notwithstanding differences in the rapidity of the process, the lake

is undoubtedly being filled up, and the present environmental and biotic conditions are being changed toward those of the river flood-plain.

Station IV. South of Carp Lake the country is covered by the biota of the deciduous forest type which is essentially the same as on the north slope. The small spring brooks which drain the region, however, bring in a different set of conditions, and may be considered as representative of the headwater conditions of the larger streams. The two studied on Sections 23 and 28, T. 51 N., R. 43 W., are shallow, cold, swift flowing streams from 6 to 15 feet wide with a bottom composed of gravel and stones. The biota is limited in variety probably owing principally to the coldness of the water. There is practically no aquatic vegetation, and the fauna consists chiefly of the snail, *Planorbis parvus*, caddis—and stone-fly larvae, and the frogs, *Rana septentrionalis*, *clamitans*, and *R. sylvatica cantabrigensis*. On the banks of these streams, however, the conditions are much more favorable. The deciduous trees usually overtop them entirely, so that the humus conditions along the margin are essentially the same as in the forest with the exception of a considerable increase in the moisture content. The flora that lines the creek is composed of such forms as *Caltha palustris*, *Equisetum sylvaticum*, *Cinna latifolia*, *Onoclea sensibilis*, *Scirpus cyperinus*, *Osmunda claytoniana*, Skunk Cabbage, *Carex crinita* and *pubescens*, and large mats of *Conecephalus conicus* and *Endocarpon miniatum*. Behind this narrow zone occur occasional clumps of alders (*Alnus incana*), and Mountain Maple.

The molluscan fauna of the creek bank is characterized principally by an increase in the abundance of the forest forms, while among very wet leaves *Physa sayii* is occasionally found.

It will be noticed that the biota of the creek bank is composed of members of the alder, sedge and forest societies of the river valley, but that the forms of the cassandra and coniferous societies are apparently lacking.

Station VII. Practically the same conditions prevail in Little Carp Lake as in Carp Lake, although its smaller size probably affects the biota to some extent. The deciduous forest forms extend down the sides of the bordering hills nearly to the waters edge. Between the forest and the water there is a narrow zone of vegetation the most conspicuous form of which is the Hoary Alder (*Alnus incana*) which is associated with the Few Flowering Cranberry, etc. The rush society in the margin of the water and on the delta (which is mostly submerged) is composed principally of *Equisetum* (*fluviatile* where examined) but for a short distance along the south shore the Canada Rush becomes prominent. As a rule, the aquatic societies are not extensive, the vegetation of the rush societies is scattered even on the delta, while the pond lily zone is only occasionally present.

The bivalve, *Anodonta marginata*, is quite commonly found about the margin of the lake, especially on the delta. The most characteristic fish, at this time of the year, are the Sucker and Horned Dace, the latter being very abundant.

Station VII. Substation 2. Above the lake, Little Carp river is a small meandering stream about 15 feet wide and 2 feet deep. It enters the lake through a narrow valley about one-fourth of a mile long which is crossed at the east end by several beaver dams. Above these dams, the valley widens out into an amphitheater about a mile long by one-fourth mile wide. In the narrow part of the valley near the lake, the space between the river and the foot of the adjacent ridges is occupied by a dense thicket of Hoary Alder, (*Alnus incana*). As the valley widens out above the dams, this alder zone, composed now of the Hoary Alder, *Betula glandulosa*, and several willows, is

separated from the mesophytic forests of the slopes by a coniferous society of Tamarack, White Spruce, White and Black Ash, and follows closely the foot of the ridge. The floor of the valley is occupied by a broad beaver meadow, covered with a luxuriant growth of grasses, sedges and other herbaceous forms, Fig. 20.

Among the conspicuous forms in this meadow may be mentioned *Carex monile, filiformis* and *viridula, Juncus effusus* and *tenuis, Agrostis hyemale, Calamagrostis canadensis, Scirpus cyperinus, Deschampsia flexusa, Panicularia canadensis, Solidago neglecta* and *erecta*, and the Marsh Bellflower, Joe Pye Weed, Swamp Milkweed and Nodding Ladies Tresses. The fauna is composed chiefly of the butterflies, *Basilarchia arthemis, Vanessa antiopa* and *Argynnis cybele*; the dragon-flies, *Sympetrum obtrusum* and *Aeschna clepsydra*; the grasshopper, *Camnula pellucida;* and the amphibians, *Hyla pickeringii* and *Rana clamitans*. This is also the habitat of the Song and Swamp Sparrows, and there was abundant evidence that it was a favorite feeding ground for deer.

Station VII. Substation 3. The dams at the west end of the beaver meadow are not now in repair, so that they influence but little the nature of the river, except as small pools, four or five feet deep, are formed behind them, where the current is deflected to one side. In these pools the characteristic fish is *Couesius plumbeus*, although the Sucker is sometimes found. The fauna of the river, in harmony with the conditions, is composed mostly of brook and creek forms, such as the Shiner, *Nototropis cornutus*, and the Dwarf Stickle Back, *Eucalia inconstans pygmaea*. There is very little aquatic vegetation.

The mud flats along the river are small and practically devoid of vegetation with the exception of scattered grasses, such as *Dulichium arundinaceum* and *Calamagrostis canadensis*, on the dryer portions. The birds that were observed here were the Solitary and Least Sandpipers and the Yellow-legs. On the submerged edges of these flats, the characteristic form is the mollusc *Sphaerium simile* with which is occasionally associated *Anodonta marginata*.

The meadow is the result of an extension of the conditions that normally prevail on the wetter parts of the flood-plain, and with this extension of the habitat there is associated an increase of the grass and sedge zones. When the dams, which are largely formed of Hoary Alder, were constructed, the flood-plain in the broad part of the valley was flooded, and this ponding of the stream resulted in the killing off of the dryer flood-plain flora. It is not probable that the pond covered the entire valley, but the low adjacent ground between the pond and the sides of the valley would be saturated and subjected to floods, making the conditions favorable for the grasses and sedges and an associated fauna, so that a small meadow analagous to the present one probably existed about its margin.

No evidence of the extent of the pond now remains, for with the trapping off of the Beaver the dams were no longer repaired and were broken through by the river. The pond was thus drained and the water resumed its former channel. This resulted in better drainage and a consequently dryer substratum in the meadow, so that the meadow forms were able to follow the water as it retreated, while the conditions are, at the present time, becoming favorable for the higher flood-plain and deciduous forest forms, that are working in about the margin. That the encroachment of the forest forms will ultimately destroy the meadow by narrowing the habitats of the grass and sedge societies, is evident from an examination of the conditions in localities where the Beaver formerly occurred. For instance, there have

been no Beaver on Carp river within the memory of several of the trappers in the region, and yet several of the bends of the river were found to be due to the remains of old dams which were once evidently of considerable size. Now a slight raising of the water level in this valley, such as would be caused by these dams if they were in repair, would cause the plain to be flooded, the trees to be killed off and either a pond or meadow would result according to the height of the dam. It thus seems probable that the present flood-plain societies of Carp river have reoccupied the flood-plain since the Beaver were killed off, which suggests that the history of the meadow on Little Carp river will be similar.

6. SUMMARY.

In order to get at the relation between the physical changes and the biota of the region as a whole, it will be necessary to summarize the present conditions, the biota, the processes that are dominant in the different habitats, and the changes which they are bringing about.

I. Beach. The beach consists of tilted strata of rock that are exposed to the forces of weathering and the action of waves. It may be divided into three parts on the basis of the processes acting upon it. The Lower Beach is exposed to the pounding of the waves, that tend to break up the rock and carry the fragments back in the undertow, building them up in a submarine terrace. The Middle Beach is exposed to the action of waves only during the winter months; during the summer months the forces of weathering predominate and tend to form a soil. This soil tends to be removed during the winter with the exception of a small amount that accumulates in the edges of the joint planes. The Upper Beach is, at present, above the reach of both summer and winter waves and is chiefly exposed to the forces of weathering, which have formed a slight residual soil.

The biota of the beach as a whole is adapted to the conditions that prevail in this habitat, and may be divided into three groups that are closely associated with the physiographic divisions. There is practically no life on the Lower Beach, owing to the pounding of the waves. The life on the Middle Beach consists for the most part of annuals that can obtain a foothold during the summer on the slight soil in the crevices, and a few associated animal forms. The flora of the Upper Beach, in response to the more favorable soil conditions and the absence of wave action, consists of a number of annuals and perennials; while the more favorable food conditions are likewise marked by an increase in the animal forms.

The changes that are taking place are due to the action of waves and weathering. The waves by cutting into the beach cause it to retreat inland, but the submarine terrace built up at the same time tends to cause this retreat to proceed more slowly in its later stages, as the growing terrace carries the breaker line off shore and tends to lessen the effect of the summer and winter waves. This is, in part, counteracted in the Porcupine Mountains by the sinking of the coast line, and the beach as a whole is moving inland. As the force of the waves is diminished, the process of weathering increases in comparative importance, the beach tends to become broken up, and the area of the habitats frequented by the crevice forms increases.

II. 1. Arbor Vitae Swamp. The narrow area back of the beach, at the foot of the north slope is not well drained, and the soil is covered by a thick layer of humus.

The forms adapted to these conditions are plants and animals found in

FIG. 13 The zone of heath plants and scattered pines, station III. 2, surrounding the bald areas, above the aspen zone, on the top of the First Range.

FIG. 14. Face of the cliff and talus slope (looking north from Carp Lake) station III. 5, showing hardwoods in the foreground on the lower part of the talus slope, the bare portion of the talus, and the belt of vegetation (pines, oaks &c.) at the foot of the cliff. The presence of the pines on the cliff show the influence of rock ledges.

swampy areas. If the undrained conditions of these areas are caused by the sinking of the coast, this habitat will tend to become destroyed by the encroachment of the beach conditions. If, on the other hand, this encroachment is relatively slow compared with other changes, the accumulation of the inwash and organic debris will tend to convert such a swamp into a dryer habitat and cause the present biota to be succeeded by a society adapted to the new conditions.

II. 2. North Slope of First Ridge. This slope on account of its relief is well exposed both to the forces of weathering and of denudation and is covered by a layer of soil that becomes thinner near the top of the ridge. Above this soil there is a layer of humus and vegetable mould that tends to conduct the water from the surface, thus greatly diminishing the effects of denudation. (It also furnishes organic constituents to the soil).

These conditions are very favorable for plant life, and the lower part of the slope is covered by a dense forest with which is associated a large number of animals. This biota is composed partly of forms whose principal distribution is in southeastern North America, and partly of those which predominate to the north of the Great Lakes and in the bogs to the south. On the thinner soil near the top of the ridge, those forms of the forest predominate that can live in the more open, poorer soil, and dryer conditions of this habitat.

The processes working on this slope tend to reduce the ridge toward base level and to increase the depth of the soil. The accumulation of humus retards the former process, while the latter proceeds more and more slowly as the soil increases in thickness. Changes are thus taking place very slowly, and the physiographic processes are evidently tending to approach an equilibrium. Near the top of the ridge, owing to thinner layers of soil and humus, the changes are more rapid but in the direction of the conditions that prevail on the lower part of the slope, and the biota adapted to these conditions is pushing up the slope.

III. Mountain Top. On the bare mountain top, the forces of weathering tend to break up the rock into a soil that is washed or blown away nearly as fast as it is formed, except along the joint planes.

The flora consists of rock inhabiting lichens and a number of crevice forms, the fauna of the types frequenting open habitats, such as the grasshoppers, etc.

The soil formed in the crevices is in part held by plant roots, and, since these soil areas are the habitats of the crevice forms of life, as they gradually spread out, the habitats of the rock inhabitating forms are restricted. At the same time, the soil washed down the slope is held at the forest margin, thus permitting the forest societies to encroach on the crevice forms which will thus in time tend to become replaced by the forest forms. This succession of forms is modified by the influence of the strong winds which tend to break down the pioneer trees on the exposed areas.

III. Cliff and Talus Slope. The cliff is constantly exposed to the forces of weathering, for as fast as the rock is broken up it is removed, exposing a fresh surface.

The fauna and flora, owing to the unstable and exposed conditions, are very poor except on the rock ledges, where a slight soil accumulates.

The talus slope at the foot of the cliff is also very unstable and is exposed to the destructive effects of falling rock fragments. Toward the bottom, beyond the limit of falling rocks, the blocks tend to become broken up into a soil.

The biota of the talus slope, on account of the unstable conditions, is also very poor. Toward the bottom of the slope the rocks become covered by a vegetation of lichens, and farther down by a slight soil and the heath and forest societies.

As the cliff is destroyed, the talus slope and the top of the ridge tend to approach. The lower part of the talus slope in time becomes broken up to form a soil, and the deciduous forest types from below tend to spread up the slope thus encroaching on the areas occupied by the cliff and talus slope forms.

IV. Carp River Valley. The sides of the valley of Carp river slope down to a low flood-plain that becomes still lower near the river, grading into mud flats along the stream. The soil is deep and contains a large amount of organic material, and there is a decrease in its moisture content from the mud flats up into the forest.

The aquatic biota is a mixture of pond and river types. The mud flats are inhabited by amphibious forms that are replaced on the dryer parts of the flood-plain by the sedge, cassandra, and alder societies, behind which usually occurs a society of Tamarack, White Spruce and White and Black Ash. On the valley slopes occurs the mesophytic forest type of biota.

The prominent forces at work in these habitats are those of denudation and deposition. The river tends to destroy the adjacent ridges and build up a part of the material derived in this way into mud flats. Deposition during high water builds these flats above the level of the water, and they come in time to form part of the flood-plain. The flood-plain is in turn built up by deposition during floods and by the accumulation of organic remains until the conditions become similar to those in the adjacent forest habitats. The effect of the processes is, therefore, to reduce the country to a level plain thus permitting the encroachment of the forest forms.

V. VII. Carp and Little Carp Lakes. These lakes on account of the similarity of conditions may be considered together. They are, for the most part, shallow throughout. At the east end of each lake, there is a broad delta formed at the mouth of the entering stream.

The aquatic biota is of the quiet water type. At the margin occur the amphibious forms that give way on the dryer ground to the flood-plain and forest forms. The deltas afford conditions similar to those on the mud flats and are occupied by a flora of grasses and sedges, and an associated fauna that is characterized by such forms as the snipes, sandpipers, etc.

The lakes are evidently being filled up, and the conditions are approaching those of the surrounding and encroaching forests.

VII. 2-3. Little Carp River. This is a small meandering stream which evidently at one time was expanded into a pond by the formation of beaver dams across it. As the Beaver were trapped off, the dams were destroyed and the pond became drained.

The biota of this stream consists of brook types. The forms on the mud flats along the stream grade into the flood-plain biota which consists principally of grasses and sedges which ordinarily inhabit the wetter parts of the flood-plain, the higher ground types being limited to a narrow zone in front of the forest.

The changes going on are evidently tending to make the flood-plain dryer, and the forest is encroaching on the meadow. The present extent of the area occupied by the meadow forms is due to the fact that they were able to push in and acquire the territory left by the receding water of the river when the dams were destroyed.

VI. Hardwood Forest. This region has been reserved to the last, for the conditions are evidently those toward which the other habitats tend to be changed under the present conditions. The conditions are similar to those on the north slope, and the whole region is covered by a similar type of biota. This society thus represents the climax society of the region. It consists of the forms that are adapted to or associated with the conditions which prevail in this region in the last stages of the mutual adjustment of all the environmental processes. As the processes become adjusted to one another, the habitat of the climax society is increased at the expense of the other habitats, and the associated biota tends to become of general geographic extent in the region.

7. INTERPRETATIONS AND CONCLUSIONS.

From the conditions of life in this region as summarized above, the following interpretations and conclusions seem justifiable.

Owing to the dependence of forms of life on their environment, biotic changes are necessarily closely related to environmental changes. These biotic changes may occur in two ways; the forms must either be able to respond to the new conditions or be supplanted by other forms. That they tend to become adjusted cannot be questioned, but in many cases at least this adjustment lags behind the changing conditions, and the forms are replaced by others from adjacent habitats which are adjusted to the conditions toward which the particular habitat is changing, thus bringing about a succession of societies.

To understand, therefore, the succession of societies in a region it is necessary to know both the environmental conditions and the processes that modify them. The environmental conditions are brought about by the association of certain environmental factors, such as the geographic, physiographic, organic, edaphic (the chemical and structural composition of the rock and the depth of the soil), time, and climatic factors. These divisions are arbitrary, for the different factors are so intimately related that they can only rarely be separated, and although certain ones may predominate in different habitats, it is impossible, owing to this interrelation, to explain the distribution of animals or plants on the basis of a single factor, for all are more or less involved in the formation of a habitat. This is one of the primary reasons for emphasizing habitat dynamics.

It will be seen by reference to Van Hise ('04, p. 40) that the environmental factors given above are the same as the geological factors in the belt of weathering. Each of these factors is the resultant of various processes (composed in turn of physical forces, heat, light, etc.) which when not in equilibrium tend to become so. The adjustment of these processes to each other brings about changes in the conditions which can only approximately cease when they approach an equilibrium, as, for example, when the topography has been reduced to a base-leveled plain covered by a layer of residual soil. The conditions in habitats where the processes are not in equilibrium are thus being constantly changed in the direction of other habitats in which they have more nearly reached an adjustment, and a succession of societies occurs that only ceases when the processes have become approximately adjusted to each other. The forms that are adapted to the adjusted conditions will constitute the climax society. It is necessary to here emphasize the importance of the organic factor; this must also become adjusted to the others for the entrance of new forms into a region may greatly change the equilibrium of its societies.

The conditions and changes that are going on in this region at the present time have been given in the discussion of the different stations, but, owing to the fact that the relation between environmental changes and the succession of societies has also prevailed in the past, the historic factor in biotic interpretation, the present conditions will not alone explain the present biotic conditions. It is therefore necessary to take into account the conditions that have prevailed in the past. This may be done by reversing the order followed in the discussion and by considering the past in the light of the action of the present processes.

The historical geology of the Lake Superior region has been worked out by Van Hise ('04), and his results are the basis of the following account. During the earliest period the oldest rocks were formed of which we have any knowledge; the crystalline schists, gneisses and granites comprising the Basement Complex (the Kewatin and Laurentian). They form in North America the broad old land area, extending, according to Wilson ('03, p. 617), from Coronation Gulf in the extreme northwest of Canada, southward around Hudson Bay, and northward through Labrador to Baffin Bay and beyond. South of Lake Superior, in Michigan and Wisconsin, there is a continuation of this area, largely buried in Michigan under later deposits but exposed in a large area in Central Wisconsin. There were at least three series of rocks formed upon the Basement Complex before the Keweenawan, but the mountains formed by the elevation and folding of these rocks were reduced to a peneplain before the Keweenawan rocks were laid down. During the period of unstable equilibrium that followed the Huronian Epoch, this peneplain was submerged, and the sediments of the Keweenawan Series were laid down. During their formation, these sediments were covered from time to time by great sheets of volcanic lavas, the products of fissure eruptions. At the close of the Keweenawan Epoch, the land was again elevated and the strata tilted to form great mountains, as is shown by the inclination of the strata in the cross section, Fig. 2. During the subsequent cycle of erosion, the entire thickness of the Keweenawan Series was greatly eroded, and the mountains together with the whole pre-Cambrian area (Wilson, '03, and Weidman, '03) were reduced nearly to sea level.

During Mesozoic times, there was a particularly well marked period of baseleveling that removed the overlying Palaeozoic sediments from the Lake Superior region and reduced the topography to a peneplain. This peneplain, the Jura-Cretaceous, extended over much of the existing land area of North America and has been recognized in Canada (Wilson, '03, p. 658), in the Ozarks (Hershey, '01, pp. 22-24), eastern (Davis, '89, p. 197) and western United States (Woodworth, '94, p. 221). At this time eastern and western North America were separated by the Cretaceous Mediterranean Sea. At the close of the Cretaceous Period, the continent was unified by an elevation of the interior which banished the Mediterranean Sea and put an end to the Jura-Cretaceous peneplain; but in the Tertiary Period that followed, another cycle of erosion occurred which, although not complete in the mountainous regions of North America, sufficed to reduce the northern part of the continent nearly to baselevel (Upham, '04). The surface of the earth in the Great Lakes region at this time probably became covered by a thick mantle of residual soil, owing to the enormous length of time during which it was subjected to disintergrating processes.

The present elevations in the Porcupine Mountain region are evidently formed by the projecting edges of the more resistant basic and acidic lava sheets, while the valleys of Carp and Union rivers are sunk by erosion into

a softer inter-bedded clastic. This contrast between the resistance offered by the sandstone and trap sheets to erosion has given rise, in a small degree, to what Marbut ('96, pp. 29-32) has called step and platform topography. The cross section, Fig. 2, shows that the first ridge is formed by the projecting end of a stratum of trap; if this sheet had been vertical, erosion would have been equal on both sides and the slope on either side would have been the same. But, owing to the fact that the sheet is inclined, the outcropping edge protects the underlying sandstone and a precipitous escarpment is formed. This section also shows that the valley of Carp river is formed by the erosion of the softer stratum of sandstone lying between the escarpment and the second ridge of trap, and that the stream runs along the strike of the rocks, so that it is difficult to believe with Dr. Wright ('05, p. 38) that the valley was formed by the submarine erosion of post-glacial lakes.

If the second sheet of trap was, like the first, underlaid by a bed of detrital material, another escarpment would have been formed. But instead of overlaying an interbedded clastic, it overlies the hard resistant quartziferous porphry that constitutes the central part of the mountainous district. This results in the topography that would prevail if the resistant stratum were vertical, i. e. equal slopes on either side. The topography, however is not of recent origin, and although the physiographic history of this part of Michigan has not been worked out by geologists, one is lead to believe from the work of Wilson in Canada ('03), Weidman in Wisconsin ('03), and Van Hise in northern Michigan ('94 and '96) that the baselevel that is represented by the truncated strata, Fig. 2, probably represents a pre-Cambrian peneplain.

Prof. C. K. Leith has suggested to me in a letter that this structure possibly represents a peneplain of later age than the Wisconsin pre-Cambrian, which it probably intersects at a low angle in a manner similar to the intersection of peneplains of different ages about the Laurentian of Canada as described by Wilson ('03, p. 651). The Porcupine Mountains would thus represent the remains of a peneplain, buried since early geological time under later deposits.

But whether the topography is of pre-Cambrian or later age, it is largely determined by the geological structure and has been comparatively little modified by the ice age. Thus Van Hise ('04, p. 35) has shown that the rocks at present exposed in this part of the Lake Superior region were buried under later deposits all through the Palaeozoic Era and had probably become approximately adjusted to those conditions. Later when they were brought to the surface by the extensive denudation of Cretaceous and Tertiary Periods, and still later when the thin layer of weathered material had been removed by the ice sheets of the Glacial Epoch, this equilibrium was disturbed, and they at once began to adjust themselves to the new conditions—a process that is not yet completed.

At the close of the Tertiary Period, the Tertiary peneplain was destroyed by an elevation of 3,000 to 5,000 feet (Upham, '04, p. 244) over northern North America. Near the culmination of this uplift, three centers of ice accumulation developed in this region and gave rise to the continental ice sheets of the Glacial Epoch.

The glaciers that were formed from these three centers covered Canada and invaded the northern part of the United States at various times, but the final invasion was the most important from the standpoint of the present biota. At this time, ice sheets fed by the different centers united into a

single sheet, the Wisconsin, that covered Canada and moved southward over northern United States, forcing the biota before it. As the ice from the Labradoran center reached the Great Lake region, it was broken up into lobes, the direction of which was determined by the lake basins. The Superior Lobe traveled southwest to the end of the lake. It then spread out laterally, united with the neighboring lobes and moved southward as a continuous sheet.

Thus during the inception of the ice age, certain forces gradually became dominant, throwing the environmental processes out of adjustment, changing the conditions so that the northern forms were able to encroach on the habitats of the more southern societies, thus resulting in a general southward movement of the biota. At the same time, the habitats of the northern forms were destroyed, and their societies were forced southward beyond the limits of glaciation. It may be inferred, from the fossils of boreal forms now found in Pleistocene deposits near the margin of the ice sheet (Adams, '05, p. 55), that the societies during the ice age became adjusted, in a general way, to the conditions beyond the ice margin. But, as the glaciers finally retreated the equilibrium of environmental processes was again disturbed. The conditions changed in favor of the more southern forms which were thus able to extend their habitats into those previously occupied by the boreal types. At the same time, the habitats of the northern forms were extended by the retreat of the ice sheet and a northward migration began (Adams, '02) In this migration the extreme northern types were probably in the lead, and the barren ground left by the retreating glacier was invaded, in all probability, by the lemmings, voles, moles, ptarmigan, etc., representative of the tundra. As the glacier continued to retreat and the conditions became more favorable, the habitats of the tundral types were probably encroached upon by the hares, porcupines, chipmunks and the Lincoln's, White-throated and White-crowned Sparrows, etc., now characteristic of the northern boreal forest of Spruce, Balsam Fir and Tamarack. This biota was in turn succeeded by the deciduous forest type that includes the dominant forms of life in Indiana, Illinois and southern Michigan today. As these southern forms moved northward, they often surrounded groups of boreal plants and animals, as illustrated by tamarack swamps or bogs. These swamps are characterized by a distinctly northern biota consisting of such forms as the Southern Varying Hare, Star-nosed Mole, Red-backed Mouse, Cassandra, Tamarack, Spruce, etc., and are really boreal islands (Bailey, '96) surrounded by the deciduous forest types in the northward migration (Adams, '02, and Transeau, '03).

When the receding edge of the glacier reached the Great Lake region, it was broken into lobes that retreated up the lake basins. As soon as the lobes had retreated beyond the southern watersheds of the Great Lakes, the water accumulated in front of each lobe as an ice dammed lake which drained through the lowest point in the divide (Taylor, '05, p. 97). The lake formed in front of the Superior Lobe drained by way of the St. Croix river through the Mississippi to the Gulf, thus forming a highway for the migrating forms into the Lake Superior region. The Porcupine Mountains, however, owing to the height of the St. Croix outlet, were entirely surrounded by the lake (Wright, '05, p. 38). As the ice retreated, an eastern outlet was opened lower than the St. Croix, and the level of the lake descended; during this descent successive beach lines were cut about the Porcupines until they were finally united with the mainland.

Meanwhile, as the continental ice sheet continued to retreat north of the

Great Lakes, it was followed by plants and animals, so that when it finally disappeared the different forms of life were left distributed in a north and south direction approximately in the order of their northward migration. The wide distribution of the boreal forms in northern North America is thus seen to be very intimately related to the character and extent of the peneplained nature of the region.

Toward the south, with the retreat of the last ice sheet, the boreal forms became restricted to local areas, as in bogs for example. but further north they tend to become of wider distribution. This is shown in the Porcupine Mountains by the general distribution of forms that about Ann Arbor, Michigan are confined to the tamarack swamps, by the presence of boreal forms in the climax forest to the exclusion of more southern forms, and by the fact that there are few forms restricted to the bog societies. That this spreading out of the conditions with which the boreal forms are associated affects the more nearly related habitats first is shown by the number of boreal forms in the flood-plain biota while on the higher ground the southern forms become more numerous. When the present biotic types reached this region, the various societies took possession of the different habitats to which they were adapted, but, owing to the fact that the processes were not in equilibrium these societies could not remain fixed. This is shown, at the present time, where the changes were taking place rapidly, as for example on the mountain top, by the fact that the conditions are being changed in the direction of those that prevail on the low land, and the biota of the cliff habitats is being supplanted by the deciduous forest types which occupy the lower levels where the processes approach an equilibrium. As the processes approach an adjustment, the changes take place more slowly, and the more resistant forms may persist for a considerable time in the succeeding society, as is shown by the presence of the isolated White Pines in the deciduous forest. The deciduous forest society thus represents the climax biota in the Porcupine Mountains, as it is associated with those conditions toward which the other habitats are tending.

From the dynamic nature of the processes that give rise to the environmental factors in the different habitats, it follows that a study of the distribution of forms in a particular region should be made from the standpoint of the processes involved, and, since the conditions in particular habitats may become of geographic extent, the same methods are applicable to general distributional problems. This leads naturally to the conclusion so well expressed by H. R. Mill ('05, p. 10) for geography in general: "Geography was defined long ago as the science of distribution; but the old idea was statical distribution, the laying down on maps of where things are; now we see that we ought to go further and discuss also how the things got there, why they remain there, whether they are in transit and if so how their path is determined. We are learning to look on distribution from its dynamical side, the earth with all its activities being viewed as a machine at work."

PART II. ISLE ROYALE.

1. GENERAL GEOGRAPHY.

Isle Royale is situated in the northwestern part of Lake Superior on the junction of the 89th degree of west longitude with the 48th degree of north latitude, Fig. 21. It lies northeast and southwest nearly parallel to the north shore of the lake. The topography is striking; several nearly parallel ridges separated by broad valleys run the length of the island, and project out into the lake at either end (more conspicuously at the north) as the walls of deep fiords. These ridges are all low, the highest not exceeding 500 feet. The geology and topography have been discussed by Lane ('98) and Irving ('83), and it is sufficient for this report, to say that the topography, as in the Porcupine Mountains, is closely dependent on the geological structure. The ridges consist of the centers of outcropping sheets of lava, while the valleys between are mostly cut in the inter-bedded clastics as in the Porcupine Mountains. The dip of the rocks, is however, toward the Michigan shore, and the escarpments are thus on the north instead of the south side of the ranges. These escarpments are not precipitous in the southern part of the island. There is abundant evidence that the entire island was overridden by the ice sheets of the glacial epoch and that after the final retreat of the glacier it was entirely submerged beneath the Pleistocene Lakes (Lane, '98, pp. 183 and 184). It has not since that time been connected with the mainland, a fact to which many of the peculiarities of its biota are probably due.

2. LOCATION OF FIELD STATIONS. (FIG. 21).

Only the southwestern end of the island was examined. Stations were established as follows:

Station I. Clearing on the Shore of Washington Harbor, Section 29, T. 64 N., R. 38 W.

Station II. Washington River, Section 29, T. 64 N., R. 38 W.

Station III. Trail along the Top of Greenstone Range, T. 64 N., R. 38 W.

Station IV. Washington Creek, Sections 28 and 32, T. 64 N., R. 38 W.

Station V. Tamarack Swamp, Section 20, T. 64 N., R. 38 W.

Station VI. North Slope of Greenstone Range, Section 32, T. 64 N., R. 38 W.

Station VII. Lake Desor, T. 64 N., R. 32 W.

Station VIII. West End of Siskowit Bay, T. 64 N., R. 32 W.

Station IX. Southwestern End of Minong Trap Range, Section 30, T. 64 N., R. 39 W.

Station X. Washington Harbor, T. 64 N., R. 38 W.

3. THE BIOTA CONSIDERED BY STATIONS.

Station I. Clearing on the Shore of Washington Harbor. This station *will not be discussed* as it is an artificial clearing into which cultivated species

FIG. 15. Large rock ledge on the face of the cliff shown in Figure 14, illustrating the character of the vegetation on a cliff that is broken by ledges.

FIG 16. Talus slope, station III. 5, showing the nature of the talus. The influence of the unstable character of the slope upon the vegetation is indicated by the fallen pines.

have been introduced, and which is kept open, so that only in a few places can the succession of forms be observed that would occur if the clearing was left undisturbed. There is evidence, however, in several places, that the pioneer forms are the Quaking and Large-toothed Aspens, and the Paper and Yellow Birch. The animals taken here were probably all forms from adjacent habitats (see annotated lists).

Station II. Washington River. This river is a sluggish meandering stream flowing through a broad flat valley between the Greenstone and Minong Trap Ranges, and emptying into the head of Washington Harbor. The aquatic vegetation is very poor. In the quiet water near the mouth of the river, *Myriophyllum sp.* forms the principal vegetation with *Sparganium eurycarpum,* and *Phragmites communis* in the shallow water near shore. These forms are replaced on the mud flats by a zone of sedges and herbaceous forms, among the conspicuous forms of which are *Carex tribuloidea, retrorsa, intumescens* and *trisperma, Juncus effusus,* Joe Pye Weed, *Esclepias incarnata,* and *Spiraea salicifolia.* This society is not extensive but soon grades into the dense thickets of Hoary Alder (*Alnus incana*) that are characteristic of the flood plains in this region. The undergrowth in these thickets is limited to a few forms such as *Caltha palustris,* Skunk Cabbage, *Vagnera trifolia,* and several species of ferns and violets. Where the flood-plain is broad, as toward the mouth of the river, the alder thickets are followed by a society of White and Black Spruce, Tamarack, White and Yellow Birch, and Black Ash, with an undergrowth of *Taxus canadensis,* Mountain Maple, *Andromeda polyfolia, Mitella nuda,* Dwarf Dogwood, *Coptis trifolia, Chiogenes hispidula, Ledum groenlandicum, Vaccinium canadensis,* and *Viburnum opulus,* on a thick carpet of moss. As the valley narrows toward the head of the river, this zone gradually disappears.

As in the case of the flora, the aquatic fauna is limited both in individuals and species. The birds are represented by the Pied Billed Grebe, American Coot and American Merganser; the molluscs by *Planorbis exacuous* and *Physa sp.* among the leaves of aquatic plants, and *Pisidium variabile* and *Pisidium spp.* on the mud bottom. Among the alders are found the sparrows, warblers and thrushes; the toad, *Bufo americanus;* the garter snakes, *Thamnophis sirtalis sirtalis,* and *T. sirtalis parietalis,* and the molluscs, *Carychium exile, Pisidium abditum, Apecta hypnorum, Pyramidula striatella, Zonitoides arborea* and *exigua, Vitrea binneyana* and *Agriolimax campestris.* In the tamarack and spruce forest, the birds are not so numerous, and the sparrows, thrushes and warblers tend to be replaced by the Arctic Three-toed, Downy and Hairy Woodpeckers, the Crossbills and the Sharp-shinned and Sparrow Hawks. Among the molluscs, *Pisidium abditum, Apecta hypnorum* and *Carychium exile* also seem to drop out in this zone, but *Pyramidula striatella, Vitrea binneyana, Zonitoides arborea* and *exigua* were found associated with *Euconulus fulvus* and *E. chersinus polygyratus, Sphyradium edentulum, Acanthinula harpa* and *Pyramidula striatella alba.* Here also the grasshopper, *Tettix acadicus,* and the spider, *Amaurobius bennetti,* are occasionally found in the moss.

Station VI. North Slope of Greenstone Range. On account of the intermediate relation which it bears to the flood-plain of Washington river, Station II, and the top of the Greenstone Ridge, Station III, this station will be considered here. The Tamarack and Black Spruce are replaced on the sides of the valley by a forest composed principally of the Balsam Fir, White Spruce, Paper and Yellow Birch, and large isolated White Pines. The undergrowth consists principally of the Ground Hemlock associated

with the Beaked Hazel and Mountain Maple, forming dense thickets that are almost impenetrable, and in exposed situations, particularly about the shores of the island, with the Mountain Ash. Less conspicuous forms in the undergrowth are the Twin Flower, Rattle Snake Plantain, Dwarf Cornel, *Mitella nuda*, *Coptis trifolia*, *Clintonia borealis*, *Lycopodium annotinum* and *clavatum*, and *Chiogenes hispidula*. The birds are represented chiefly by the Nuthatch, Brown Creeper, and the Downy, Hairy, Arctic Three-toed and Pileated Woodpeckers; the molluscs by *Pyramidula striatella*, *Zonitoides arborea*, and *Vitrea binneyana;* the reptiles by *Storeria occipitomaculata;* the amphibians by the common toad, *Bufo americanus*, and the mammals by the Canada Lynx, Hudson Bay Red Squirrel, Canadian White-footed Mouse and Hudson Bay Varying Hare.

Station III. Top of Greenstone Range. Toward the top of the slope the White Spruce decreases in abundance and the Balsam Fir and Birches become associated on the top of the ridge with a large predominance of Sugar Maple. This forest extends as a narrow strip along the top of the ridge and contains the only Sugar Maples observed on the island. The undergrowth is essentially the same as in the Balsam Fir and Spruce forest of the slopes, and the only difference in the fauna is the greater development of molluscs; the forms collected are *Pyramidula striatella*, *P. striatella alba* and *alternata*, *Zonitoides arborea*, *exigua* and *milium*, *Vitrea binneyana*, *Euconulus fulvus* and *E. chersinus polygyratus*, and *Sphyradium edentulum* among the fallen leaves, and *Vertigo gouldii*, *Punctum pygmaeum*, *Carychium exile* and *Vitrina limpida* in the damp humus in the small ravines. Other forms that may be listed here, although they also occur in the Balsam Fir and Spruce forest, are Storer's Snake (*Storeria occipitomaculata*), the garter snakes, *Thamnophis sirtalis sirtalis* and *T. sirtalis parietalis*, and the grasshoppers, *Tettix acadicus* and *Ceuthophilus seclusus*.

Station IV. Washington Creek. The conditions represented here are similar to those which prevail on the head waters of the rivers and along the small streams. Where the valley is narrow (near the mouth, Section 32) the forms of the slope forest extend nearly to the waters edge, being separated from it by a narrow zone of Hoary Alder, *Equisetum arvense*, *Caltha palustris*, *Vagnera trifolia*, *Rhamnus alnifolia* and various grasses and sedges. Up stream, Section 28, the valley is wider, and the coniferous forest of the slope is separated from the stream by a considerable development of bog forms. The arboreal vegetation consists of the Arbor Vitae, Tamarack and Black Spruce, with an undergrowth of *Coptis trifolia*, *Chiogenes hispidula*, *Linnaea borealis*, *Lycopodium clavatum* and *obscurum*, and a thick carpet of *Sphagnum* and other mosses.

There is practically no aquatic flora, and the only aquatic animals found were *Pisidium*, too young to identify.

The molluscs collected in the bog society are *Pyramidula striatella*, *Zonitoides arborea* and *exigua*, *Vitrea binneyana*, *Acanthinula harpa*, *Vertigo gouldii*, *Agriolimax campestris* and *Pallifera hemphilli*.

Station V. Tamarack Swamp. On Section 20, T. 64 N., R. 38 W., in the valley of the small stream draining into Huginnins Cove, the bog society attains a considerable development. The Tamarack is the principal tree and is associated with the Balsam Fir, Black Spruce and Black Ash. The undergrowth consists of the Dwarf Dogwood, *Chiogenes hispidula* and *Coptis trifolia* on a thick mat of *Sphagnum* and other mosses. The molluscs found here are *Zonitoides exigua*, *Z. arborea* and *milium*, *Vitrea binneyana*, *Euconulus fulvus*, *Vertigo gouldii*, *Pyramidula striatella* and *Euconulus chersinus poly-*

gyratus. A conspicuous feature of the bogs in this region is the lack of undergrowth. As may be seen from the list of species, the forms that compose the undergrowth consist only of a few herbaceous forms, which is in striking contrast to the density of the undergrowth in the surrounding forest.

Station VII. Lake Desor. This lake lies between the Greenstone and Minong Trap Ranges. Its shores are for the most part shelving and covered with a fine silt-like deposit. The islands, however, have uniformly rocky shores. The coniferous forest of the slopes comes down to the margin of the lake where it grades into a narrow zone of Hoary Alder, *Viburnum opulus* and Arbor Vitae that lines the shores. The aquatic flora and fauna is very poor. The marginal forms consist of the plants, *Equisetum sp.*, *Phragmites communis*, *Sparganium curycarpum*, and occasionally the White Water Lily (*Castalia odorata*); the frog, *Rana sylvatica cantabrigensis*, and the molluscs, *Planorbis bicarinatus striatus*, and *Anodonta marginata*. On the rocky shores of the islands, the vegetation consists of a scattered growth of *Isoetes sp.* and *Phragmites communis* in the water among the rocks, and *Equisetum arvense* on the rocks in exposed places. The animals collected here are the leeches, *Haemopis grandis* Verrill and *Nephelopsis obscura* Verrill, a number of caddis fly larvae, and the molluses, *Planorbis hirsutus*, *P. exacuous* and *parvus*, and *Physa sp.*

Station VIII. Siskowit Bay. The only part of Siskowit Bay worked was the west end in T. 64 N., R. 32 W. The shore at this point consists of outcropping strata of conglomerate that dip under the bay, and are often broken up into shingle beaches. Owing to the grinding of the waves, there is practically no aquatic life, although a small *Physa* is sometimes found on the larger rocks. In the pools that occur occasionally along this beach behind the outcropping strata, the conditions are more favorable. Small mats of Algae may occur on the rocks and there is a limited fauna of which caddis fly larvae, and molluses, *Physa sp.* and *Valvata sincera lewisii*, are the principal forms. The beach flora is also very limited, consisting chiefly of Juneberry, *Phegopteris polypodiales*, *Euthamia graminifolia*, *Campanularia rotundifolia* and *Listera convallariodes* that occur in the rock crevices and scattered over the shingle beach.

Station IX. Southwestern End of Minong Trap Range. As may be seen on the map, the Minong Trap Range on Section 30, T. 64 N., R. 39 W. projects into Lake Superior, becoming deeply submerged several hundred yards from the mainland. It is also sloping on the south side, owing to the dip of the strata, but on the north side it is precipitous. Near the outer end of the ridge, there are a number of rock pools in the angular spaces formed by the removal of portions of the rock between the joint planes. These are very similar in form and probably in origin to the beach pools in the Porcupine Mountains. The flora of these pools is very limited, but a number of animal forms are found such as the molluses, *Limnaea sumassi* and *Planorbis parvus*, the water strider, *Gerris remigis*, and caddis-fly larvae. The flora on the outer end of the ridge consists of scattered patches of *Parmelia conspersa*, and a crevice vegetation of *Sibbaldiopsis tridentata* and *Dasiphora fruticosa Campanularia rotundifolia*, *Solidago sp.*, Arbor Vitae and several grasses.

Toward shore a thin soil covers the rock and supports a flora of Reindeer Lichen (*Cladonia rangiferina*), and the heaths, Bearberry, Dwarf Blueberry and New Jersey Tea that are often found growing on the remains of lichen mats. Here also are found *Empetrum nigrum*, and *Lycopodium annotinum*, *clavatum* and *complanatum*. The first tree is the Arbor Vitae

that grows nearly prostrate on the rock, associated with *Juniperus nana*, Mountain Ash, White Pine, and Quaking Aspen. Near the shore the White Spruce, Balsam Fir and Paper Birch come in, forming the forest of the region. The succession on these points is evidently represented by four stages, the lichen-moss, grass-sedge, heath, and coniferous societies. The history of the pools is somewhat different. There is evidence that these are being filled in places by *Sphagnum* and other mosses, and on this moss such bog forms as *Ledum groenlandicum*, Cassandra, Black Spruce and Tamarack are occasionally found. These forms must, however, in time be succeeded by the forms of the upland forest.

In listing the fauna of the outer end of the ridge, the Herring Gull should be mentioned as one of the most characteristic forms, for hundreds of individuals were often observed on this ridge during the summer. As in the Porcupine Mountains, a number of molluscs push out in advance of the forest on the heath mat. In the dry soil among the roots of these plants was found, *Pyramidula striatella*, *Zonitoides exigua*, *Vitrea binneyana* and *Acanthinula harpa*.

Station X. Washington Harbor. As may be seen from the map, Washington Harbor is a long narrow bay lying between the Minong Trap and Greenstone Ranges, on the southwest end of the island. It attains a depth of 6 to 9 fathoms and has a rocky bottom that rises nearly to the surface in places as reefs.

The fauna of the deeper waters, as represented by the collections, consists of the Lake and Brook Trout, Herring, Sucker, Muskallunge, Yellow Perch and *Couesius plumbeus*. Among the rocks near shore the Millers Thumb (*Cottus ictalops*) is found, and the molluscs, *Limnaea stagnalis var.*, *Limnaea summassi*, *Physa sayii*, *Physa sp.* and *Planorbis exacuous*. Of these forms the two Limnaeas were the most characteristic and were particularly abundant on the northeast end of the harbor.

4. SUMMARY AND CONCLUSIONS.

On account of the preliminary nature of the work done on Isle Royale, but few conclusions will be drawn. It will be seen at once, however, that while the biota of the Porcupine Mountains possess many southern forms, the Isle Royale societies are characteristically boreal, the bog forms are less restricted, the sedge, cassandra, shrub and coniferous societies are better represented on the river flood-plains, and many of the forms of the coniferous society occur in the climax forest. This makes the climax forest society of Isle Royale, of the northeastern North American type. The bog forms are thus boreal types having the same affinities, and their spreading out in this region from the restricted habitats which they occupy to the south may be accounted for by the fact that the environmental conditions with which they are associated, toward the north tend to become of general or of geographic extent, so that these forms ultimately come to form the climax society. Thus several forms that about Ann Arbor have been recorded only from tamarack swamps, such as the snails, *Philomycus dorsalis*, and *Pallifera hemphilli* (collected by Miss Jean Dawson), and the Varying Hare, Star-nosed Mole, and Red Backed Mouse, are all boreal species (Bailey, '96), that toward the north tend to become of general distribution.

It will be noticed in the annotated lists, however, that while most of the species have northeastern affinities, a number of forms collected on Isle

Royale are forms of western and northwestern distribution. There are conspicuous examples of this:

1. The snail listed as *Limnaea sumassi* Bd., according to Mr. Bryant Walker, although probably entitled to rank as a distinct variety or species, is very closely related to *L. summassi* Bd. a peculiarly western form originally described from British Columbia.

2. The range of the ant, *Camponotus herculeanus* L. var. *Whymperi* Forel, according to Dr. Wheeler, is not well known, but it has been previously found in the mountains of Colorado and Britsh Columbia.

3. The specimens of the Garter Snake, *Thamnophis sirtalis parietalis*, taken on the island strikingly resemble in coloration western forms from Washington and Colorado, and not those of southern Michigan, that are sometimes referred to this variety.

4. Although not found on the island, the Michigan Grayling, *Thymallus ontariensis*, may also be mentioned in this connection. According to Jordan and Evermann ('96, p. 518), this variety "represents a detached colony left from the post glacial extension of the range of *T. signifer*, of which it was a variety." The range of *T. signifer* is given as "Mackenzie River to Alaska and the Artic Ocean."

5. Another instance of the same nature was the finding of the Devils Club, *Echinopanax horridus* Decsene, by Wheeler ('01, p. 620) on the north end of the island in 1900. The range of this plant, as given by Macoun ('83, p. 189), is the north coast of America and in Alaska; being abundant west, but extremely rare east of the Rocky mountains.

The occurrence of these western and northwestern elements in the biota of Isle Royale is emphasized because, as was said before, the majority of the species are those of the northeastern North American type. Whatever may be the explanation of the occurrence of these western and northwestern forms this far to the east, an important factor is, no doubt, the peneplain nature of the country, which probably formed an extensive highway for boreal forms along the ice margin during the retreat of the last ice sheet.

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THE ECOLOGICAL DISTRIBUTION OF THE BIRDS IN THE PORCUPINE MOUNTAINS, MICHIGAN.

OTTO McCREARY.

The country in which these observations were made is largely included within a narrow area about a mile wide which runs from Lake Superior almost directly south, crossing Carp river about a quarter of a mile east of Carp Lake. Few observations were made south of the Carp river valley.

On account of differences observed in the environments of the bird life of this region, it will be discussed according to the following habitats:

I. THE LAKE SUPERIOR SLOPE OF THE FIRST MOUNTAIN RIDGE.

1. Lake Superior }
2. Lake Beach... } .....Station I.
3. Cedar Swamp.....Station II. Sub. 1.
4. Hemlock Forest.....Station II. Sub. 2.
5. Hardwood Forest.....Station II. Sub. 2.
6. Camp Clearing.....Station II. Sub. 3 and 4.
7. Mountain Top and Escarpment.....Station III. Sub. 1-6.

1. Lake Superior (Station I).

This habitat includes the open water of the lake and is only a feeding place for the birds, as it is impossible for them to nest here.

The water is very cold, the temperature being about 58° F. during the latter part of July. The shores are rocky and steep, the rocks in some places making an angle of 30° with the surface of the water, and on this account, aquatic life, with the possible exception of small algae and invertebrates, was lacking along the edge of the water, so that waterfowls feeding on these would be expected to occur here only occasionally, during the migration season.

The only birds observed, were those of fish eating habits, such as mergansers, loons and gulls. On July 21 a female American Merganser with nine or ten young in the down was seen near the shore. On my approach they swam out into the lake and were soon out of sight behind some rocks that jutted into the water. Two adult Loons were seen the same day, and two days later two Herring Gulls were observed flying over the lake. These were the only birds seen in about fifteen trips made to the lake shore from July 15 to August 13.

2. Lake Beach (Station I).

At this part of the lake shore, the beach is formed by the dipping of the bed rock below the lake, thus making a barren reef almost destitute of vegetation, between the waters edge and the [illegible] to the mosses and lichens that grew upon the rocks. [illegible] that

occurred here were goldenrods bluebells, lobelias, etc. that grow in the crevices.

The scarcity of small invertebrates and plants suitable for bird food made this a very poor feeding ground. Indeed the scarcity of bird life here was especially noticeable, as only three birds, the Spotted, Solitary and Least Sandpipers were seen, all of which are shore birds.

Ravens, Crows and Chimney Swifts were seen flying along the shore; the last was probably searching for insects and the first two for fish. Although no dead fish were seen along the shore, no doubt they are occasionally washed up, and these birds were probably patrolling the coast in search of cast up refuse.

3. Cedar Swamp (Station II. 1).

This station extended from the lake beach to the hemlock forest, a distance varying from a quarter to a half mile at different places. The trees were mostly arbor vitae, spruce, Canada balsam and birch, the principal forms being the arbor vitae and balsam. There were several clearings in this substation, and, as the bird life was different at such places than in the woodland, I shall divide this station into two parts, the Woodland and the Clearings.

Woodland.

In some places the woodland has been partially cleared, but where no lumber has been taken out the woods are very dense. The same species of birds, with one or two exceptions, were found in the dense forest as in the open woodland, only there were fewer of them in the former forest. In the very dense forest birds of all species were few and far between. The birds found here were Mangolia Warbler, Black-throated Blue Warbler, Redstart, Winter Wren, Canadian Warbler, Olive-backed Thrush, Golden-crowned Kinglet, Myrtle Warbler, White-throated Sparrow, Brown Creeper, Oven Bird, Crow, Hairy Woodpecker, Purple Finch, Red-eyed Vireo, Cedar Waxwing, Chickadee, Wood Pewee, Ruffed Grouse, Black-throated Green Warbler, Sharp-shinned Hawk, Pileated Woodpecker, Pine Siskin, Mourning Warbler, Raven, and Red-breasted Nuthatch, and Arctic Three-toed Woodpecker. The Black-throated Blue Warbler is characteristic of the undergrowth. The Pine Siskin and Purple Finch were nearly always seen in flocks and roamed about over a large expanse of territory.

The Olive-backed Thrush, Mourning Warbler, Wood Pewee and White-throated Sparrow were found in the open woods.

Clearings in the Cedar Swamp.

There were several clearings in this vicinity, most of them being near the lake. In all of them there were plenty of small trees and brush, in which the birds found favorable conditions.

The birds seen in the clearings were, Black-throated Blue Warbler, Winter Wren, House Wren, Arctic Three-toed Woodpecker, Red-tailed Hawk, Sparrow Hawk, White-throated Sparrow, Crow, Flicker, Purple Finch, Red-eyed Vireo, Chickadee, Canadian Ruffed Grouse, Song Sparrow, Great Horned Owl, Sharp-shinned Hawk, Sparrow Hawk, Pileated Woodpecker, Pine Siskin, American Bittern, Raven, Least Fycatcher, Olive-sided Flycatcher and King Bird.

The Bittern was a straggler, observed once near the lake shore. The Red-tailed Hawk, Raven and Pine Siskins were seen flying overhead, and

the Flickers on the high dead stumps in the clearing. The Purple Finch came to the clearing to feed on the raspberries, and one was shot with part of a berry in its mouth.

Supplementary Clearing Observations.

This clearing is about two miles west of the main line of observation, and one-half mile south of Lake Superior. The conditions here were decidedly swampy, as cat-tails grew in the middle of the logging road in many places. The arbor vitae had been cleared away several years before and the second growth had become quite a factor in the conditions. This growth, together with the underbrush and tree tops, made traveling outside of the logging road very difficult. Here, among a young growth of maple about five or six feet high, was found a family of four Connecticut Warblers.

Other birds seen in this clearing are as follows: Blue-headed Vireo, Red-breasted Nuthatch, Black-throated Blue Warbler, Pileated Woodpecker and White-throated Sparrow.

4. Hemlock Forest (Station II. 2).

This habitat may be called the hemlock belt because the majority of the trees were of this species. The lower part of this station, at the edge of the cedars, was covered with a dense growth of hemlock, while farther up the side of the mountain the proportion of maples increased until finally the hemlocks were nearly all replaced by maples. In the dense hemlock forest there was very little underbrush, but where there were many maples there was always a thick underbrush of young maples and some basswood.

The birds of this Station were: Pine Siskin, Red-eyed Vireo, Cedar Waxwing, Purple Finch, Black-throated Blue Warbler, Chickadee, Hairy Woodpecker, Golden-crowned Kinglet, Brown Creeper, Blackburnian Warbler, Black-throated Green Warbler, Winter Wren, White-throated Sparrow, Oven Bird, Wilson's Thrush, Ruffed Grouse, Olive-backed Thrush, Raven, Pileated Woodpecker, Broad-winged Hawk.

Here, as in the cedars, different species of birds frequented certain places. The Pine Siskins, Purple Finches and Golden-crowned Kinglets were nearly always seen in the hemlocks. The Winter Wrens were observed mostly along streams and in damp places. The Black-throated Blue Warbler was found quite commonly in the underbrush, but where the dense shade prevented an undergrowth, none were observed. The Olive-backed Thrush and White-throated Sparrow were always found in the open woodland.

Supplementary Clearing Observations.

This was a clearing in the hemlock forest about two miles west of the main line of observation and about a quarter of a mile south of Lake Superior.

The birds seen in this clearing were the Purple Finch, Olive-sided Flycatcher, Least Flycatcher, White-throated Sparrow, Song Sparrow and Ruffed Grouse. The Olive-sided Flycatchers were seen sitting on high dead stubs making themselves conspicious by their noise.

5. Hardwood Forest (Station II. 3).

This habitat extended from the hemlock belt through the maples to the aspens about the natural clearing at the top of the cliff. This may be called *the hardwood* belt because the trees were mostly maple with a few scattered *hemlocks, basswood,* balsam, and birch. In these [illegible] there was a very *thick undergrowth* composed mostly of young ma[illegible]

The birds observed in this habitat are: Black-throated Blue Warbler, Oven Bird, Black-billed Cuckoo, Cedar Waxwing, Red-tailed Hawk, Flicker, Wilson's Thrush, Red-eyed Vireo, Black-throated Green Warbler, Blackburnian Warbler, Brown Creeper, Chickadee, Pileated Woodpecker, Ruffed Grouse and Olive-backed Thrush. An Oven Bird's nest containing two eggs and one young was found along the path up the mountain on July 16. It was made of coarse grass and leaves, and was placed on the ground. The Olive-backed Thrush, Black-billed Cuckoo, and Flicker were seen near the camp, where the woods were more open.

6. Camp Clearing (Station II. 3-4).

This was the clearing around the camp. It was not more than two acres in extent and was surrounded by a zone of aspens, except on the north where the trees were mostly maple. It was situated at the crest of a low mountain pass, a little more than 750 feet above the level of Lake Superior. It was bounded on the north by Station II. 2, and on the east by II. 2, and III. 1; on the south by IV. 3, and on the west by II. 2, and III. 5; It contained many tall weeds, bushes, and several trees, principally aspen.

The birds found on this station were: Purple Finch, Mourning Warbler, Blackburnian Warbler, Red-eyed Vireo, Black-billed Cuckoo, American Crossbill, Song Sparrow, Downy Woodpecker, Pine Siskin, Sapsucker, Robin, Raven, Sparrow Hawk, Indigo Bunting, Chimney Swift and Cedar Waxwing. The Song Sparrow, Sapsucker and Indigo Bunting were probably accidental here, as only one of each was observed. The Chimney Swift was often seen flying overhead. The Purple Finches and Pine Siskins came to feed on bread crumbs and other refuse from the camp. A pair of adult Mourning Warblers and two young were taken among the bushes in the clearing, July 15.

7. Mountain Top and Escarpment (Station III. 1-6).

From the top of the mountain to the valley of Carp river, there is a precipitous descent of about 400 feet. On top of the cliff and back a few rods from the brink of the precipice, there are no trees except a few scattered pines. The chief vegetation consists of dwarf huckle and blueberries, New Jersey tea, bearberry and other heath plants. The cliff is nearly continuous, but not entirely so, being broken occasionally by gullies. Surrounding the "bald" top of the cliff is a zone of aspen which grades down into the gullies, and down the north slope into the hardwoods. At intervals, where the slope is not so steep, the pines form a narrow belt up the face of the cliff, across the top of the mountain and into the hardwoods beyond, thus surmounting the range.

It is the top of the cliff on the eastern half of Section 14 and western half of Section 13 (III.1, 2, 3) that will be described first.

The western end of the station lies in a gully in Section 14. As the top is approached the aspens become smaller and smaller and finally disappear. Toward the east end of the mountain top, on Section 13, this "bald" area is crossed by a zone of Norway and white pines, many of them being of very large size. The middle portion consists of a precipice and a narrow strip at the top. It differed from the west end in that it contained no aspens, and the pines were so far apart that they had but very little influence upon the general conditions. Probably owing to this reason the bird life on the west end and middle portion was practically identical, and I will describe them together, treating the bird life in the pines separately, as it is entirely different.

Birds were always to be found along the western slope and top III. 1 and 2, but the small number of species was noticable. The Junco, Cedar Waxwing and Flicker were the only birds that were abundant. The Flicker was often seen on the few tall dead stumps and scattered pines that occurred here, and probably nested in these stumps, as they contained many holes. Both young and adult Juncos were found in abundance and this seemed their natural habitat. The Cedar Waxwing was attracted here by the Juneberries, upon which they were often seen feeding. Crows, Ravens, Chimney Swifts and Red-tailed Hawks were seen flying overhead. Sparrow Hawks came occasionally to feed upon the grasshoppers, but these birds seem to prefer the cliffs to the west of this location.

The birds seen in the pines (III. 3) were the Pine Warbler, Red-breasted Nuthatch, Chickadee, Chipping Sparrow and White-breasted Nuthatch. Two Pine Warblers, evidently a male and female, were seen on the tops of these pines looking for insects. Finally one caught an insect, but instead of eating it the bird perched on a limb, held the insect in its mouth, and scolded. It acted as if it had young near me and was afraid to feed them. Several Chipping Sparrows were seen on the tree tops and one was shot July 19.

The tops of the cliffs west of camp (III. 5) were similar to III. 2, except that the "bald" areas were of greater extent. The same birds that were found in III. 1 and 2 were found here and also a few additional ones.

For some reason, which I cannot explain, Robins, Bluebirds, Blue Jays and Vesper Sparrows were often found on this cliff and seldom in Station II. 1 and 2. A Bluebird's nest containing young was found in a deserted Woodpecker's hole in a Norway pine; Vesper Sparrows and a Scarlet Tanager were seen here once. The former were perhaps migrating, (August 3), while the latter was from the neighboring forest. The Ravens came here in the evening and left in the morning, when nine were counted at one time. A few could be seen about here at almost any hour of the day.

The bird life on the second cliff west of camp was somewhat different from that of the first as no Robins, Bluebirds, or Vesper Sparrows were seen here, while a Phoebe was seen here and not on the other cliffs. Two Bald Eagles were observed flying overhead.

II. CARP RIVER VALLEY.

This region extended from the foot of the talus slope south to the elevation on the other side of the river valley, a distance of about a quarter of a mile. From west to east, it extended from the outlet of Carp Lake as far up the Carp river as we could ascend in a boat, a distance of about one and a quarter miles.

Within this area are included several different varieties of conditions, and these furnish the basis for the following habitats:

1. Carp Lake.....Station V. 1, and 3.
2. Grassy Marshes.....Station V. 2, and IV. 2.
3. Alders.....Station IV. 2.
4. Damp Woodland.....Station IV. 3.
5. Tamarack Swamp.....Station IV. 4.
6. Carp River.....Station IV. 1.
7. Dry Woodland.....Station IV. 3.
   a. Western End.
   b. Eastern End.

FIG. 17. Upper portion of the talus slope, station III, 6, showing the angle of slope, and the lichens (light colored patches) on the rocks. The birches in the background are on the lower part of the slope.

FIG. 18. General view of Carp river valley, looking up stream and southeast from station III, 5. Note the alder and cassandra vegetation bordering the river, station IV, 2.

1. Carp Lake (Station V. 1 and 3).

The lake is about a mile long, a quarter of a mile wide, and comprised, in extent, about one-half of the station. The western half of the lake extended from the foot of the talus slope to the foot of the ridge on the other side, while the eastern half differed from it principally in having a narrow strip of land between the waters edge and the foot of the talus slope on the north side.

Bordering most of the lake there is just enough beach to walk on, except on the northwest shore where it is somewhat wider. On the southwest and southeast shores of the lake, there are small grassy marshes, and at such places bulrushes and sedges grow along the edge of the water.

On the south side arbor vitae, maples, alders, and other trees grow along the edge of the beach. These trees were usually not more than twenty feet high and are so close together that it was almost impossible to penetrate them. At other places there is a fringe of alders along the beach.

Very few birds were seen on the lake; a Loon, was upon the water August 10; Kingfishers were often seen flying across the lake, now and then diving for a fish; an Osprey was observed several times doing the same thing, and a Great Blue Heron was twice seen flying across the lake and once in the sedges. A Swamp Sparrow, a Solitary Sandpiper and Crows were observed on the beach.

2. Grassy Marshes (Station V. 2, IV. 2).

There were two of these grassy marshes. One at the east end of Carp Lake and another a mile and a quarter up Carp river. Both were overgrown with tough marsh grass and were too small to be of any special importance as a bird habitat.

Song Sparrows and Swamp Sparrows came out of the alders to feed but the only birds taken characteristic of grassy marshes were the Wilson's Snipe and Carolina Rail. The former was taken in the marsh, up the river, and the latter in the marsh at the east end of the lake.

3. Alders (Station IV. 2).

The alders occupied the bottom land along either side of Carp river. There are many willows, dogwoods, and cassandra bushes among the alders, and together they formed a thicket so dense, that it was impossible to see more than a few yards.

The birds of this habitat were the White-throated Sparrow, Red-eyed Vireo, Black-throated Green Warbler, Redstart, Oven Bird, Swamp Sparrow, Mourning Warbler, Olive-backed Thrush, Downy Woodpecker, Kingfisher, Sharp-shinned Hawk, Cedar Waxwing, Chestnut-sided Warbler, Chickadee, Canadian Warbler, Rose-breasted Grosbeak, Wilson's Thrush, Black-billed Cuckoo, Alder Flycatcher, Song Sparrow, American Bittern, Ruffed Grouse, Least Flycatcher, Red-winged Blackbird, Water Thrush, and Black-throated Blue Warbler.

The Canadian and Chestnut-sided Warblers and Red-winged Blackbird probably did not breed in this zone, as they were not seen here until after the first of August.

The Kingfisher, American Bittern and Sharp-shinned Hawk were seen along the edge of the river. Only one of each of the last two were seen. The Hawk was on the bank eating a grouse and the Bittern was standing

on an alder that leaned out over the river. Kingfishers were often seen flying up and down the river and would alight upon the overhanging branches to watch for fish.

A Cedar Waxwing's nest was found in an alder. This nest was made of mud and dead grass and was built in the top of the shrub. The nest was found July 28, but contained no eggs.

Almost all of the birds among the alders appeared quite tame, for as soon as I would go into the bushes some bird would begin to scold, nearly always a White-throated Sparrow, and the rest of the birds would come to see what the trouble was about. Redstarts, Mourning Warblers, Black-throated Green Warblers, Oven Birds, Red-eyed Vireos, Swamp Sparrows, Song Sparrows, Wilson's Thrushes, Winter Wrens, Water Thrushes and a Rose-breasted Grosbeak came within a few feet of me. Even the shy Olive-backed Thrush would come within a rod to scold. It was very interesting to observe the marked curiosity which they showed.

4. Damp Woodland (Station IV. 3).

This was a small strip of maple and ash between the alders, and the maple forest of the slopes. The birds seen here were: Red-eyed Vireo, White-throated Sparrow, Winter Wren, Water Thrush, Black and White Warbler, and Least Flycatcher.

The trees of this piece of woodland were not very high but were so crowded that they produced a dense shade. This was perhaps the reason why there were so few birds seen here, and why those seen were near the margin.

5. Tamarack Swamp (Station IV. 4).

About a half mile east of the lake where the river turns to the south, there is, on the west bank, a tamarack swamp. The trees of this swamp are arbor vitae, and tamarack, which about the margin of the swamp grow much thicker than in the center.

The birds observed were as follows: Purple Finch, White-throated Sparrow, Magnolia Warbler, Cedar Waxwing, Red-breasted Nuthatch, Red Crossbill, White-winged Crossbill, Olive-sided Flycatcher, Pine Siskin, Golden-crowned Kinglet and Ruffed Grouse. The two species of Crossbills were probably attracted here by the seeds of the tamarack cones, as the crops of five specimens all contained tamarack seeds. The Red-breasted Nuthatch nested here, as an adult bird was seen feeding three young. The Olive-sided Flycatchers were seen on the tops of tall dead trees.

6. Carp River (Station IV. 1).

About a mile and a quarter east of Carp Lake, the river becomes so narrow that the alders which line the banks meet above the middle of the stream and obstruct further passage with a boat. Where the alders line the bank there were few places for wading birds, but where there were grassy mud flats between the water and the shrubs Solitary Sandpipers were to be seen at almost any time. The Snipe, however, was only seen July 17 and 18. The only birds seen on the river were Hooded Mergansers.

7. Dry Woodland (Station IV. 3, North of Carp River).

This is the upper part of the strip of woodland lying between the cliff *and Carp Lake, on the* north side of the valley, and occupies the lower part

of the talus slope. The trees here were mostly maple, birch and aspen, with a few pines scattered among them. At the eastern end the forest was open, while the trees of the western end were so close as to make a dense shade. On account of the difference of the character of the two portions, they will be taken up separately.

Western End. Here, where the trees were thick, few birds were seen. The different species noticed were as follows: Blackburnian Warbler, Kingfisher, Sparrow Hawk, Red-eyed Vireo, Wilson's Thrush, Canadian Warbler, Blue Jay and Redstart. There was a Sparrow Hawk's nest situated high up in a dead tree, in what seemed to be a deserted Woodpecker's hole. The young of the Wilson's Thrush, still unable to fly, were found here.

Eastern End. The birds found in this end of the forest were: Black-throated Blue Warbler, Robin, Ruffed Grouse, Flicker, Downy Woodpecker, Oven Bird, Olive-backed Thrush, Red-eyed Vireo, Black-billed Cuckoo, Blackburnian Warbler and White-throated Sparrow. In the evening and morning the song of the Olive-backed Thrush could be heard almost everywhere in the tree tops, and they seemed to be quite numerous, but in the daytime this bird was seldom heard. The probable explanation of this is that they went into the alder thickets to the south.

III. HARDWOOD FOREST SOUTH OF CARP RIVER (STATION VI.).

The trees along the trail to Government Peak were mostly maple, birch and hemlock, except in low places along the small streams, where there was much arbor vitae and balsam.

Observations along the trail were made July 26 and the following birds were seen in the forest: Oven Bird, Golden-crowned Kinglet, Scarles Tanager, Red-eyed Vireo, Magnolia Warbler, Black-throated Blue Warblert Wood Pewee, Winter Wren and Olive-backed Thrush. The Magnolia, Warbler, Wood Pewee and Winter Wren were seen along a stream.

An Olive-backed Thrush's nest was found on top of a small hemlock about ten feet high beneath a larger tree. The nest was composed of leaves, rootlets, and grasses, and was lined with still smaller grasses and rootlets, and contained two bluish green eggs with cinnamon brown spots.

IV. LITTLE CARP RIVER VALLEY.

1. Little Carp Lake (Station VII. 1).

This lake is small, being about one-half mile long and a quarter of a mile wide. The only observations made upon the bird life on the lake shore were in an open spot at the east end. Only one bird was seen on the water, a Pied-billed Grebe, on August 2.

The open area was at the foot of a small hill which arose precipitously out of the lake to a height of about fifty feet. There was very little soil, which accounts for the absence of an extensive vegetation. Observations were made on August 2 and 3 and the birds seen were: Blue Jay, Junco, Humming Bird, Yellow-bellied Sapsucker, Hairy Woodpecker, White-throated Sparrow, Wood Pewee, Purple Finch, Chimney Swift, Raven, Kingfisher, Cedar Waxwing, Flicker and Song Sparrow. The Chimney Swift and Raven were seen flying overhead.

2. Beaver Meadow (Station VII. 2 and 3).

This meadow was along Little Carp river, about a quarter of a mile east of Little Carp Lake. It was about a mile long and a quarter of a mile wide, the Little Carp river running through the middle of it. The ground was quite marshy in many places and was covered with grass, there being no trees in the meadow. There were several willow and alder bushes at the east end. The surrounding trees were alder, tamarack, arbor vitae, balsam and birch.

Observations were made on August 3, and the birds seen here were: Kingfisher, Solitary Sandpiper, Cedar Waxwing, Red-eyed Vireo, Swamp Sparrow, Song Sparrow, White-throated Sparrow, Marsh Hawk, Pine Siskin, Hairy Woodpecker, Tree Swallow, White-winged Crossbill, Yellow-legs, Least Sandpiper, Red-breasted Nuthatch.

The Kingfisher, Solitary Sandpiper, Least Sandpiper, and Yellow-legs were seen along Little Carp river. The Tree Swallow, Marsh Hawk and Pine Siskin were seen flying overhead, and the Song Sparrow and Swamp Sparrow were seen feeding in the grass, while the rest were seen in the trees around the edge. The Crossbills were seen in tamarack trees at the edge of the marsh. As it was August 3 when I was at the beaver meadow, I cannot say which birds bred there and which were migrants.

V. SUMMARY.

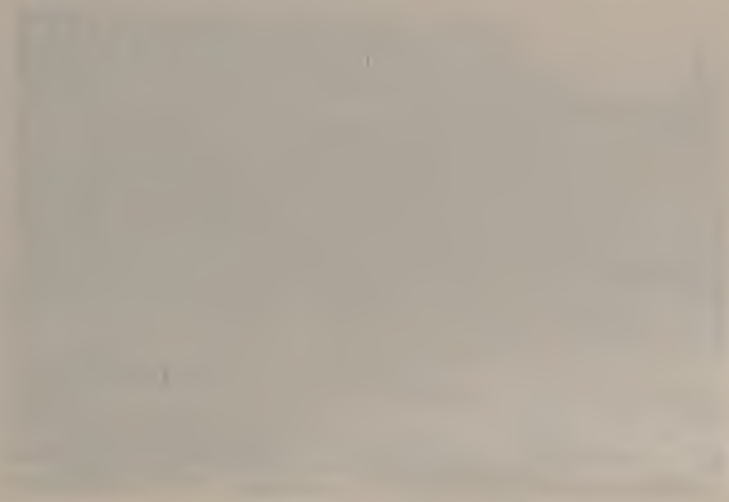
On glancing over the list of birds found at the different stations, it will be noticed that some birds were found at only one or in a few stations, while others were found in nearly all of them. At some stations a certain species of bird would be quite numerous, while another only a short distance away, would contain none of these. From such facts we must conclude that some birds are found only in certain situations which possess definite environmental conditions. There were also a number of birds observed which were too rare to determine what kind of localities they preferred; still others were only seen flying overhead. Regarding abundance, at one extreme were the rare forms and at the other those found almost everywhere. The rare birds were: Myrtle Warbler, Great Horned Owl, Black and White Warbler, Indigo Bunting, Broad-winged Hawk, Humming Bird, Arctic Three-toed Woodpecker, Connecticut Warbler, Blue-headed Vireo, Rose-breasted Grosbeak, Scarlet Tanager, House Wren, King Bird, White-breasted Nuthatch and Phoebe. The birds only seen flying overhead were: Red-tailed Hawk, Chimney Swift, Bald Eagle, Tree Swallow and Marsh Hawk. The birds of general distribution were: Ruffed Grouse, Red-eyed Vireo, Black-throated Green Warbler, Chickadee, Purple Finch, Black-throated Blue Warbler, Sharp-shinned Hawk, Cedar Waxwing, Oven Bird and Wilson's Thrush.

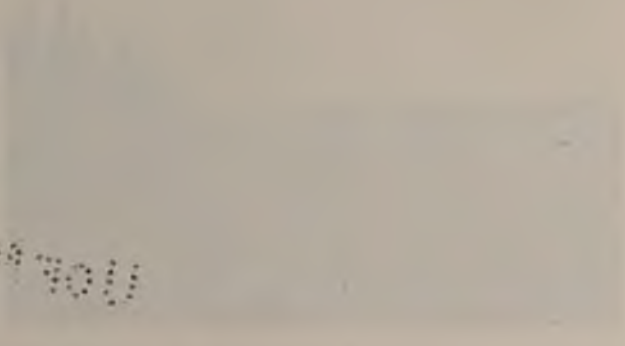
In the case of birds with a restricted range, the limiting area was occasionally very sharply defined, while in other cases it was difficult to recognize these limits. Examples of the former are the water and shore birds, of the latter, the Golden-crowned Kinglet and Pine Siskin. The distribution of the water and shore birds was the most sharply defined, and, as they are the simplest to place, I will begin my summary with them. In connection with these I will also mention other birds found in association with the shores of the lakes and rivers.

1. Water Birds. Of the water birds only a few species were observed. *The Herring Gull, Loon* and American Merganser were found on Lake

FIG. 19. Carp river, station IV, showing zones of vegetation on the mud flats

FIG. 20. Beaver meadow, station VII. 2, showing grasses and sedges bordered by encroaching willows and alders. Tamarack and spruce in the background.





Superior. A Loon was once seen on Carp Lake and a Pied-billed Grebe was seen on Little Carp Lake. The only water bird found on the rivers was the Hooded Merganser which was taken on Carp river.

Although not an aquatic bird, I will mention the Osprey here as it was seen flying over the water. It was first seen near the mouth of Union river and afterwards over Carp Lake. It would circle around above the water until it saw a fish and then it would plunge into the water after it. As far as observed most of these efforts were successful.

2. Birds Frequenting Shores and Banks of Streams. Shore birds were most abundant along Carp and Little Carp rivers; only a few were seen on the lake beaches. The Solitary Sandpiper was the only one seen in all the places mentioned. The Lesser Yellow-legs was seen only along Little Carp river. The Least Sandpiper was seen along Little Carp river and on the Lake Superior beach. The Spotted Sandpiper was seen only on the Lake Superior beach. These birds were always seen near the waters edge except when on the wing. A Snipe was seen at the edge of the water along Carp river, in the neighborhood of a grassy marsh.

Another bird that was characteristic of the rivers and small lakes was the Kingfisher, which was nearly always seen at the edge of the water, but never on the ground. It always lit on some bush or tree, and was most frequently seen on trees overhanging the water. The Great Blue Heron was seen standing on the edge of Carp Lake once, and several times it was seen flying over.

Besides the birds characteristic of the waters edge, birds from the alders and birds of general distribution were often observed on the beach of Carp Lake and Lake Superior. This includes such birds as the Song Sparrow, Swamp Sparrow, Crow and Raven.

3. Birds Found in Grassy Marshes and in Alders. Closely associated with the birds of the water's edge were the birds of grassy marshes and alders along the streams. The birds often seen in the grassy marshes were the Wilson's Snipe, Rail, Song Sparrow, and Swamp Sparrow. The Rail was only seen once in the grassy marsh east of Carp Lake.

The Song Sparrow and Swamp Sparrow are not confined to the grassy marshes, since both were also found in the alders. The Song Sparrow was also found in the camp clearing (Station III. 3) and in one of the clearings in the arbor vitae swamp (Station II. 1), so that the Song Sparrow may be said to inhabit clearings both natural and artificial, and the Swamp Sparrow may be said to inhabit marshy clearings. In this case I have classed the alders as a natural clearing because there were no trees among the bushes.

The only bird confined to the alders was the Alder Flycatcher, but several others, of limited distribution, were found here, such as the Redstart, Swamp Sparrow, Mourning Warbler, Olive-backed Thrush, Black-billed Cuckoo, Least Flycatcher, Song Sparrow, and Water Thrush.

The Redstart was rather common here and among the cedars near the shore of Lake Superior (Station II. 1) and was also seen along Little Iron river. It seems to keep near water and near the ground, as it was very seldom seen in the high trees.

The Mourning Warbler was found here, but also in the bushes of the camp clearing, and along the path to the lake in the cedar swamp (Station II. 1). Thus it is seen that this bird is not usually found in thickly forested woodland but is more decidedly a bird of the bushes or thickets.

The Olive-backed Thrush was found on the mountain top, in the river

valley, and in the bushes around the edge of the clearings or in partially cleared woodland. In the mornings and evenings it also appeared abundant among the scattered trees at the base of the talus slope. It was never found in dense woodland.

The Black-billed Cuckoo was often seen among the alders, in the scattered trees at the foot of the talus slope, and in the aspens surrounding the camp clearing. These facts show that it was a bird of the open woodland.

The Least Flycatcher was found in the alders and in a clearing in a hemlock forest; the former a natural, and the latter an artifical clearing. It was also seen in damp woodland south of Carp river, on the edge of a clearing.

The Water Thrush was seen in two other localities, the damp woodland south of Carp river, and along the road to Ontonagon near Lake Superior.

4. Birds Frequenting Tamarack Swamps and Cedar Swamps. The lowlands have all been dealt with, with the exception of the tamarack swamps and cedar swamps. The former was not entirely true to its name, as about half of the trees were cedar. The birds of these swamps deserving mention are as follows: Magnolia Warbler, Canadian Warbler, Sparrow Hawk, and Olive-sided Flycatcher, Red-breasted Nuthatch, Red Crossbill, White-winged Crossbill, Winter Wren, White-throated Sparrow, Golden-crowned Kinglet and Pine Siskin.

The Magnolia Warbler was found only in the cedar and tamarack swamps or along small streams where the arbor vitae grew.

The Canadian Warbler was found near Lake Superior shore and near Carp Lake and always in the more or less open woods.

The Sparrow Hawk was seen in a clearing among the cedars, and had a nest just south of the cliff in a limbless tree which stood above the tops of the surrounding trees. It was also often seen on the top of the cliff and around the camp clearing.

The Olive-sided Flycatcher was found in the tamarack swamp in Carp river valley and in a hemlock clearing near Lake Superior. It was always seen on the top of a dead tree, usually on the highest perch in the neighborhood.

The Red-breasted Nuthatch was seen in the tamarack swamp, and among the pines at the top of the mountain. It can, therefore, be classed with the birds characteristic of the coniferous forests.

The Red, and White-winged Crossbills were numerous in the tamarack swamps, the White-winged Crossbill being seen only in such places. The Red Crossbill came to the camp clearing several times. The cause for their occurrence in the tamaracks is that these are the only conifers whose seeds could be obtained for food.

The Golden-crowned Kinglets and Pine Siskins were very abundant among the coniferous trees, and were seldom seen where these were lacking. The Pine Siskin occasionally came to the camp clearing.

The Winter Wren and White-throated Sparrow were found in the lowlands and about half way up the mountain side. The White-throated Sparrow frequented the open woodland and the edge of the clearings. The Winter Wren was found in the more dense parts of the forests and near streams.

5. Birds Frequenting Hemlocks and Maples. Nearly all the birds that were found in these two stations were also found in the cedar swamp to the north (II. 1) or belonged to the list of rare birds. There were a number of birds that were generally distributed in all the woodland between the Lake Superior and Carp river which, with the exception of the Blackburnian Warbler,

seemed to be more abundant in these two stations. To this class belong the following: Oven Bird, Blackburnian Warbler, Hairy Woodpecker, Brown Creeper and Pileated Woodpecker.

6. Birds Frequenting the Cliff and Mountain Top. The birds characteristic of this station were the Raven, Pine Warbler, Robin, Bluebird, Flicker, Junco and Chipping Sparrow.

The two specimens of Pine Warbler, which were observed several times, were always found among the pines that grew on the top and south slope, so it may be said to be characteristic of the pines.

The Robin and Bluebird were often observed on the bare top of the cliffs, and occasionally the Robin was seen in the camp clearing near by. The Robin and the Bluebird are early migrants and may have settled here because it was on the south side of the mountain and well exposed to the sun and protected from the north winds.

The Flicker was found here and in a clearing along the south shore of Lake Superior. The Junco was abundant here and was seen in a dry sandy clearing near Ontonagon. It was also abundant on the dry knoll at the edge of Little Carp Lake so that this bird and the Flicker may be said in this region to inhabit dry clearings. They are also examples of the tendancy of natural clearing birds to spread into the artificial clearings.

The Chipping Sparrow was found here among the pines and on the dry knoll above mentioned.

The Blue Jay was found on the south slope of the cliff from the top to the edge of Carp Lake and on the dry knoll.

I have here only attempted to give the distribution of the birds as I found them in the Porcupine Mountains. The distribution of many of these birds may be very different in other localities. This would be an interesting field for study in other regions.

I am under obligations to the University Museum for the opportunity to make these observations, and I am also much indebted to Mr. Charles C. Adams for assistance in preparing this paper for publication.

THE ECOLOGICAL RELATIONS OF THE ORTHOPTERA IN THE PORCUPINE MOUNTAINS, MICHIGAN.

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1. GENERAL REMARKS.

The Orthoptera collected by Mr. A. G. Ruthven in the Porcupine Mountains represent two families of the *Saltatoria* and comprise two species of *Locustidae* and 14 species of *Acridiidae*. The collection was made between July 13 and August 12, 1904. Though the list is far from complete, it may be said, in general, that the species obtained are representative elements of the orthopterous fauna of the Canadian and cooler parts of the Transition zones of the central portion of the continent. The commingling of species is especially interesting, and in itself would suffice to indicate, within relatively narrow limits, the locality from whence the collection was derived and the environmental conditions present.

While data in addition to those of date, locality, and general character of the station are lacking—no notes on individual captures or particular species and their relation to the environment in this instance being available—I have no doubt that the ecological relations of the species secured are essentially the same as in other quarters of the eastern section of the country. This judgment is confirmed by the careful collecting notes and discriminating observations of Mr. Morgan Hebard in reference to the Orthoptera of the Keweenaw Bay region (Rehn, Entom. News, Sept., Oct., 1904). I have elsewhere (Pub. No. 18, Carnegie Inst. of Wash., p. 15 et seq.) classified the Acridian societies of eastern North America and discussed some of their more salient features. The same classification is followed in the present paper.

The Acridians secured represent several distinct societies and habitats. These habitats, or complexes of environmental conditions, when viewed from the standpoint of locust biology, may be arranged in three major groups:

1. Bare rock and soil surfaces of the lake shore, clearing, mountain top, or talus slope, either wet or dry,—these are inhabited by campestral geophilous locusts.
2. Areas clothed with a low vegetal growth of grasses or other herbaceous plants, such as meadows, fields, clearings, etc., likewise varying greatly in moisture content of soil, and often extremely limited in size,—these are the haunts of campestral phytophilous locusts.
3. Thickets of shrubs or stunted undergrowth bordering forest edges and openings, either along the lake shore, about clearings, or on the mountain top,—here dwell the sylvan phytophilous species.

Of the Locustarians collected, one species is a bush-dwelling form, nearly related to the katydid; the other, a shield-backed grasshopper, is a typical thicket-inhabiting species.

As is evident from Mr. Ruthven's field notes on the general character of the stations, and also from a consideration of the station lists of Orthoptera, almost every station contains two or more locust societies. These societies comprise one or more characteristic species of locusts which find their preferred haunts within a relatively narrow range of physical conditions and are practically characteristic of such habitats. It should be pointed out, however, that in the heart of its range a species is usually more generally distributed, and less restricted to its special habitat, than elsewhere; furthermore, that accidental occurrences are not infrequent and can be correctly estimated as such only by careful observation or experience. "One swallow does not make a summer," and the capture of a single specimen of a locust in a given locality does not necessarily indicate either an austral or a boreal climate, a campestral or a sylvan habitat.

It is scarcely necessary to state that the abundance and extent of the area occupied by the various elements of the locust fauna will inevitably be affected by the physical and organic agencies controlling the condition of the environments they inhabit, and, other things being equal, will change as they change. On the advent of new conditions one of three things will happen: either the species will become adapted to its changed environment, will emigrate, or will die out in that particular spot—probably the latter. There is every reason to think that with increasing deforestation of the territory, the thamnophilous locusts will increase in numbers; and that, if settlements and clearings multiply, so will the campestral locusts.

The avenue of ingress of the orthopterous fauna into this territory, it is believed, was on the southwest, along the continuous land surface, following the retreat of glacial conditions. This avenue was probably the only practicable one open to the flightless thicket-dwelling forms, and was doubtless followed by most, or all, of the flying species as well.

For further information in regard to the biology of the Orthoptera herein mentioned, the following works should be consulted, in addition to those already referred to:

Blatchley, W. S.—The Orthoptera of Indiana.—27th Annual Report of the Department of Geology and Natural Resources of Indiana.

Morse, Albert P.—Notes on the Acridiidae of New England.—Psyche, vols. VII, and VIII.

The former of these contains a valuable bibliography.

2. STATION LIST.

Station I. Beach of Lake Superior. Species taken: *Chloealtis abdominalis, Camnula pellucida, Circotettix verruculatus, Melanoplus atlanis* and *Melanoplus femoratus.*

Habitats represented and characteristic species.

1. Exposed rock or soil surfaces: *Circotettix verruculatus,* (*Camnula pellucida*).
2. Grassy places—dry: *Melanoplus atlanis* and *Camnula pellucida.*
3. Grassy places—moist: *Melanoplus femoratus.*
4. Thickets—forest edge: *Chloealtis abdominalis.*

Station II. North Slope of First Range. Species taken:

Sub. 2.—Hardwood Forest.—*Tettix brunneri.*

Habitats represented and characteristic species.

The single species taken is not typical of forested environment, usually occurring on bare soil.

Sub. 3.—*Clearing in Saddle.* Species taken: *Chloealtis conspersa, Stenobothrus curtipennis, Circotettix verruculatus, Melanoplus extremus,* and *Melanoplus femoratus.*

Habitats represented and characteristic species. (No notes on conditions at this station have been submitted, but the habitats are probably the following:)

1. Exposed rock or soil surfaces: *Circotettix verruculatus.*
2. Grassy places—moist: *Stenobothrus curtipennis, Melanoplus extremus* and *Melanoplus femoratus.*
3. Thickets—edges of clearing (sometimes in dry, grassy places): *Chloealtis conspersa.*

Sub. 5.—*Aspen Zone Bordering Bare Mountain Top.* Species taken: *Melanoplus fasciatus.*

Habitats represented and characteristic species.

1. Thickets—usually xerophytic: *Melanoplus fasciatus.*

Station III. Top of First Range and Southern Escarpment. Species taken:

Sub. 1.—West Slope of Ridge (aspen zone).—*Chloealtis abdominalis, Chloealtis conspersa, Camnula pellucida, Melanoplus fasciatus, Melanoplus femoratus* and *Melanoplus luridus.*

Sub. 2.—Bare Mountain Top (heath and grass vegetation).—*Chloealtis abdominalis, Chloealtis conspersa, Circotettix verruculatus, Melanoplus fasciatus* and *Melanoplus islandicus.*

Sub. 3.—Zone of Pines crossing Mountain Top.—*Melanoplus fasciatus.*

Sub. 4.—East Slope of Ridge (aspen and scrub oak vegetation).—*Melanoplus fasciatus* and *Atlanticus pachymerus.*

Sub. 5.—Mountain Top.—*Chloealtis abdominalis, Chloealtis conspersa, Melanoplus fasciatus, Melanoplus femoratus, Circotettix verruculatus* and *Atlanticus pachymerus.*

Sub. 6.—Mountain Top.—*Melanoplus amplectens.*

Habitats represented and characteristic species.

1. Exposed rock surfaces:—*Circotettix verruculatus.*
2. Grassy places—(usually moist):—*Melanoplus femoratus.*
3. Thickets:—*Chloealtis conspersa* and *abdominalis, Melanoplus amplectens, fasciatus,* and *islandicus, Atlanticus pachymerus.*

Station IV. 2. Carp River Valley Flood-plain (characterized by cassandra thickets, grasses and sedges). Species taken: *Stenobothrus curtipennis, Podisma glacialis, Melanoplus islandicus, Atlanticus pachymerus, Scudderia pistillata.*

Habitats represented and characteristic species.

1. Grassy places—moist:—*Stenobothrus curtipennis.*
2. Thickets:—*Podisma glacialis, Melanoplus islandicus, Atlanticus pachymerus.*
3. Bushes, leafage of:—*Scudderia pistillata.*

Station VII. 2. Beaver Meadow along Little Carp River. Species taken:—*Camnula pellucida.*

Habitats represented and characteristic species.

1. Grassy places—moist. The species of locust taken here is not characteristic of such conditions, but it is a very common and widely distributed species in the boreal zones, and may occur almost anywhere, especially in grassy places. Its preferred haunts are on dry upland soils.

3. SYSTEMATIC LIST OF THE ORTHOPTERA.

Porcupine Mountains.

ACRIDIIDAE.

1.	*Tettix brunneri* Bol.	1 ♂, Station II.
2.	*Chloealtis abdominalis* Thom.	1 ♂, Station III., Substation 1.
	" "	1 ♂, III., 2.
	" "	2 ♂, 3 ♀, III., 5.
	(juv. spec. do.)	♀, juv. in the 5th stage, I.
	"	♂, juv. in the 5th stage, III., 2.
	"	2 ♀, juv. in the 5th stage, III., 2.
	"	♀, juv. in the 4th stage, III., 2.
	"	♀, juv. in the 5th stage, III., 5.
3.	*Chloealtis conspersa* Harr.	1 ♀, II., 3.
	" "	1 ♀, III., 1.
	" "	1 ♀, III., 1, long-winged.
	(juv. spec. do.)	♂, juv. in the 5th stage, III., 1.
	"	♂, juv. in the 4th stage, III., 2.
4.	*Stenobothrus curtipennis* Harr.	2 ♀, II., 3.
	" "	2 ♂, IV., 2.
	" "	1 ♀, IV., 2.
5.	*Camnula pellucida* Scudd.	1 ♀, III., 1.
	" "	1 ♂, I., beach.
	" "	1 ♀, I., beach.
	" "	2 ♀, VII., 2.
6.	*Circotettix verruculatus* Kirb.	1 ♀, II., 3.
	" "	3 ♂, III., 2.
	" "	1 ♂, III., 2.
	" "	1 ♀, III., 2.
	" "	1 ♀, III., 2.
	" "	1 ♀, III., 5.
	" "	2 ♂, I., beach.
	" "	1 ♀, I., beach.
7.	*Podisma glacialis* Scudd.	1 ♀, IV., 2.
8.	*Melanoplus amplectens* Scudd.	1 ♀, III., 6.
9.	*Melanoplus atlanis* Ril.	1 ♂, I., beach.
10.	*Melanoplus extremus* Walk.	2 ♀, II., 3.
11.	*Melanoplus fasciatus* Barnst.-Walk.	1 ♂, II., 5.
	" "	1 ♀, II., 5.
	" "	1 ♂, III., 2.
	" "	1 ♂, III., 2.
	" "	4 ♀, III., 2.
	" "	1 ♂, III., 3.
	" "	1 ♀, III., 3.
	" "	1 ♂, III., 4.
	" "	1 ♂, 4 ♀, III., 5.
12.	*Melanoplus femoratus* Burm.	4 ♂, II., 3.
	" "	8 ♀, II., 3.
	" "	1 ♀, III., 1.
	" "	1 ♂, III., 5.
	" "	2 ♀, I., beach.
	" "	1 ♂, I., beach.
	(juv. spec. do.)	2 ♀, juv. in the 5th stage, II., 3.

13.	*Melanoplus islandicus* Blatchl.	1♀, II., 5.
	" "	1♂, III., 2.
	" "	1♀, IV., 2.
14.	*Melanoplus luridus* Dodge.	1♂, III., 1.

LOCUSTIDAE.

15.	*Scudderia pistillata* Brunn.	1♀, IV., 2.
16.	*Atlanticus pachymerus* Burm.	1 juv. ♀, III., 4.
	" "	1♀, III., 4.
	" "	1♀, IV., 2.
	" "	1♂, III., 5.

Isle Royale.

The following species were identified from this locality; no field notes accompanied the specimens.

1.	*Tettix acadicus* Scudd.	1♀, III.
2.	*Camnula pellucida*, Scudd.	2♂, 2♀, II.
3.	*Ceuthophilus seclusus* Scudd.	1♂, III.
	" "	1♀, III.

FIG. 21. Map of lower end of Isle Royale, showing the location of field stations. Scale, 2 miles to the inch. (From U. S. Lake Survey Chart).

ANNOTATED LISTS.

LIST OF STATIONS IN THE PORCUPINE MOUNTAINS.

See Fig. 3.

Station I.—Beach of Lake Superior, Secs. 11 and 12, T. 51 N., R. 43 W.

Station II.—North Slope of First Range, Secs. 11, 12, 13, 14, 15, and 16, T. 51 N., R. 43. W.

Sub. 1.—Arbor Vitae Swamp at Foot of Slope, Secs. 11 and 12.

Sub. 2.—North Slope, Secs. 11, 12, and 14.

Sub. 3.—Clearing in the Saddle, Sec. 14.

Sub. 4.—Aspen Zone about Clearing, Sec. 14.

Sub. 5.—Aspen Zone at Top of Ridge bordering the Bare Mountain Top, Secs. 13, 14, 15, 21, T. 51 N., R. 43 W.

Station III.—Top of the First Range and the Southern Escarpment, Secs. 13, 14, 15, and 21, T. 51 N., R. 43 W.

Sub. 1.—West Slope of the Ridge on Secs. 13 and 14.

Sub. 2.—Bare Mountain Top, Secs. 13 and 14.

Sub. 3.—Zone of Pines crossing the First Range, Secs. 13 and 14.

Sub. 4.—East Slope of the Ridge on Secs. 13 and 14.

Sub. 5.—Mountain Top on Sec. 14 and 15.

Sub. 6.—Mountain Top on Sec. 21.

Station IV.—Carp River Valley on Secs. 13, 14, 23, and 24, T. 51 N., R. 43 W.

Sub. 1.—Carp River, Secs. 14 and 24.

Sub. 2.—Flood-plain, Sec. 14.

Sub. 3.—Valley Slopes, Secs. 14 and 23.

Sub. 4.—Peat Bog, Sec. 14, 23 and 24.

Station V.—Carp Lake, Secs. 15, 21 and 22, T. 51 N., R. 43 W.

Sub. 1.—Beach at West End of Lake, Secs. 21 and 22.

Sub. 2.—Delta at East End of Lake, Sec. 22.

Sub. 3.—Carp Lake, Sec. 22.

Station VI.—Mountains between the Carp and Little Carp Drainage Systems, Secs. 21, 22, 23, 27, 28, and 34, T. 51 N., R. 43 W.

Station VII.—Little Carp Drainage System, Sec. 2, T. 50 N., R. 44 W., and Sec. 34, T. 51 N., R. 43 W.

Sub. 1.—Little Carp Lake, Sec. 2, T. 50 N., R. 44 W.

Sub. 2.—Beaver Meadow along Little Carp River, Sec. 34, T. 51 N., R. 43 W.

Sub. 3.—Little Carp River, Sec. 34, T. 51 N., R. 43 W.

LIST OF STATIONS ON ISLE ROYALE.

See Fig. 21.

Station I.—Clearing on the Shore of Washington Harbor, Sec. 29, T. 64 N., R. 38 W.

Station II.—Washington River, Sec. 29, T. 64 N., R. 38 W.

Station III.—Trail along the Top of Greenstone Range, T. 64 N., R. 38 W.

Station IV.—Washington Creek, Secs. 28 and 32, T. 64 N., R. 38 W.

Station V.—Tamarack Swamp, Sec. 20, T. 64 N., R. 38 W.

Station VI.—North Slope of Greenstone Range, Sec. 32, T. 64 N., R. 38 W.

Station VII.—Lake Desor, T. 64 N., R. 32 W.

Station VIII.—West End of Siskowit Bay, T. 64 N., R. 32 W.

Station IX.—Southwestern End of Minong Trap Range, Sec. 30, T. 64 N., R. 39 W.

Station X.—Washington Harbor, T. 64 N., R. 38 W.

NOTES ON THE PLANTS OF THE PORCUPINE MOUNTAINS AND ISLE ROYALE, MICHIGAN.

A. G. RUTHVEN.

This list has been prepared from the collections and field notes of Mr. N. F. Macduff, and the field notes of the writer. To Mr. Macduff, who devoted his time to collecting and listing the plants, many of the determinations and most of the annotations are due. The writer was able to add many localities to the list while locating the different stations. We are indebted to Dr. C. A. Davis and Mr. S. Alexander for the determination of the Pteridophytes and Spermatophytes in the herbarium, and to Prof. B. Fink for the determination of the Lichens. The nomenclature followed is that given in Britton's "Manual of the Flora of the Northern States and Canada." (1901). For the general habitat conditions and associations, reference should be made to the discussion of the stations on pp. 22-40, 45-52.

1. PORCUPINE MOUNTAINS.*

Lichens

1. *Amphiloma Parmaria longinosum* Ach. Koerb. Found only in shady places on the cliff face. III.

2. *Biatora lucida* Ach. Fr. Associated with *Amphiloma longinosum* on the cliff face. III.

3. *Cladonia alpestris* L. Rabenh. Occurs in mats, covering the talus blocks toward the bottom of the slopes where a slight soil has accumulated. III.

4. *Cladonia rangiferina* L. Hoffm. Abundant on the lower part of the talus slopes with *C. alpestris*, also on ledges of the cliff that possess a slight soil. III. and in the pine zone. III. 3.

5. *Endocarpon miniatum* L. Ach. Covering the rocks in very damp places on the banks of Cary creek. VI.

6. *Gyrophora Dillenia tuberculata* L. Nyl. Only found on the cliff face, III.

7. *Lecidea lactea* Flk. This species is one of the pioneer forms on rock habitats and was found associated with *Parmelia conspersa* and *Lecanora cinerea* on the mountain top, cliff face and talus slopes. III; also on the Middle Beach of Lake Superior. I.

8. *Lecanora conspersa*. With *Parmelia conspersa* and *Lecidea lactea* on ledges on the cliff, and on the talus slopes. III. Apparently a pioneer form in rock habitats.

9. *Lecanora cinerea* L. Sommerf. A pioneer form in rock habitats.

*A list of plants [illegible] Porcupine Mountains [illegible] W. A. Burt [illegible] 1st Sess. 31st Cong. [illegible]

occurring on the Middle Beach of Lake Superior, I, and on the mountain top, cliff and talus slopes, III.

10. *Parmelia conspersa* (Ehrh.) Ach. This is the most characteristic form on rock habitats in this region. It occurs abundantly on the Middle Beach of Lake Superior, I, and on the mountain top, cliff, and talus slopes, III.

11. *Peltidea (Peltigera) aphthosa (L.)* Ach. Found quite commonly on rocks in the pine zone, III. 3, and with the Cladonias near the bottom of the talus slopes, III.

12. *Stereocaulon coralloides* Fr. On the mountain top, cliff, and talus slopes, III.

13. *Sticta pulmonaria* (L.) Schau. Occasional on the trunks of fallen tamarack trees, IV. 4.

Ophioglossaceae Presl. Adder's-Tongue Family.

14. *Botrichium virginianum* (L.) Sw. In the climax forest, II. 2, IV. 3, VI.

Osmundaceae R. Br.

15. *Osmunda cinnamomea* L. Cinnamon Fern. Occasional in the alder thickets along Carp river, IV. 2.

16. *Osmunda claytoniana* L. Clayton's Fern. In hardwood forest, II. 2, VI, (Macduff).

Polypodiaceae R. Br. Fern Family.

17. *Polypodium vulgare* L. In exposed situations, occurring commonly on the Upper Beach of Lake Superior, I; on the bald areas on the mountain top, III. 2, 5, 6; in the aspen zone, II. 5, and III. 1, 4; in the pine zone, III. 3, and on the lower parts of the talus slope.

18. *Adiantum pedatum* L. Maiden-hair Fern. Common in the mesophytic forest, II. 2, IV. 3, VI.

19. *Pteridium aquilinum* (L.) Kuhn. Brake. In open places in the forest, II. 2, IV. 3, VI, becoming more abundant in the open woods toward the top of the ranges and on the foot of the talus slope. Especially abundant in the aspen zone bordering the mountain top, II. 5, III. 1, 4. Also in the pine zone, III. 3.

20. *Asplenium trichomanes* L. Spleenwort. In rock crevices on the mountain top, III. 2, 5, 6, and on ledges and in crannies on the cliff face, III.

21. *Polystichum lonchitis* (L.) Roth. Holly-fern. In rock crevices on the mountain top, III. 2, 5, 6; on ledges on the cliff face, and in front of the forest on the lower part of the talus slopes, III.

22. *Dryopteris spinulosa* (Retz) Kuntze. In the hardwood forest, II. 2. Common.

23. *Onoclea sensibilis* L. Sensitive Fern. In the alder thickets along Carp river, IV. 2, and on the banks of Carp creek, VI.

Equisetaceae Michx. Horsetail Family.

24. *Equisetum sylvaticum* L. In the forest in the valley of Carp river, IV. 3, and on Government Peak, VI, (Macduff).

25. *Equisetum littorale* Kuehl. On the delta of Carp river, V. 2.

26. *Equisetum fluviatile* L. On the submerged part of the delta in Carp Lake, V. 2; about the margin of Carp Lake, V. 1, and about the margin and on the delta of Little Carp Lake, VII. 1.

27. *Equisetum hyemale* L. About the shores of Carp Lake, V. 1, and on the delta, V. 2.

Lycopodiaceae Michx. Club-Moss Family.

28. *Lycopodium selago* L. Common in the aspen zone, II. 5; also found in the pine zone, III. 3.

29. *Lycopodium lucidulum* Michx. A common plant in the ground cover of the hardwood forest, II. 2; VI.

30. *Lycopodium clavatum* L. Running Pine. In the arbor vitae swamp, II. 1; in the hardwood forest, II. 2, and in the aspen zone, II. 5, III. 1, 4.

31. *Lycopodium complanatum* L. Common in the aspen zone, II. 5, III. 1, 4. Often extending out on the heath mats.

Pinaceae Lindl. Pine Family.

32. *Pinus strobus* L. White Pine. Large isolated trees occur through the hardwood forest, II. 2, IV. 3, VI. More abundant in the aspen zone, II. 5. Occurs principally as a scattered growth with *P. resinosa* on the heath mats on the mountain top, on the ledges on the cliff face, and on the talus slopes, III, forming belts of denser growth where the cliff face is broken by large ledges.

33. *Pinus resinosa* Ait. Red or Norway Pine. Associated about equally with *P. strobus* on the mountain top, cliff, and talus slopes, III. Not present in the hardwood forest.

34. *Pinus divaricata* (Ait.) Gord. Labrador or Gray Pine. Several specimens observed on the heath mat on the mountain top, III. 5.

35. *Larix laricina* (Du Roi) Koch. American Larch. Tamarack. Occasional in the cassandra and alder thickets along Carp river, IV. 2, in the broader portions of the flood-plain, and about the beaver meadow on Little Carp river, VII. 2; often forming in the last two habitats a zone with *Picea canadensis* and *Abies balsamea* between the alder thickets and the deciduous forest of the slopes. Predominates in peat bogs, forming a nearly pure stand, IV. 4.

36. *Picea canadensis* (Mill.) B. S. P. White Spruce. Occasional in the arbor vitae swamp, II. 1; in the tamarack swamp, IV. 4; in the coniferous zone behind the alder thickets in the valley of Carp river, IV, and about the beaver meadow on Little Carp river, VII. 2.

37. *Tsuga canadensis* (L.) Carr. Hemlock. This tree nearly always forms a small portion of the tree cover in the hardwood forest, II. 2, IV. 3, VI. Occasionally, as at the foot of the north slope of the first range and on the south slope of the second range, it predominates, forming dense forests with little underbrush.

38. *Abies balsamea* (L.) Mill. Balsam Fir. Widely distributed, occurring, but never predominating, in the climax forest, II. 2, IV. 3, VI. It also occurs with the Spruce and Tamarack in the coniferous society in the valley of Carp river, IV. 2; about the beaver meadow on Little Carp river, VII. 2, and in the tamarack, IV. 4, and arbor vitae swamps, II. 2; being more abundant in these coniferous societies.

39. *Thuja occidentalis* L. White Cedar. Arbor Vitae. This tree occurs in the rock crevices on the Upper Beach of Lake Superior, I; occasionally on the cliff face, III, and about the margins of Carp, V, and Little Carp Lakes, VII. It is more characteristic, however, of the swampy areas at the foot of the north slope, II. 1, and in the river valleys, IV. 2, where it forms a dense and almost impenetrable growth.

40. *Juniperus nana* Willd. Low Juniper. Characteristic of the "bald" areas of the mountain top, III. 1, 2, 4, 5, 6, spreading out from the crevices as circular mats over the rocks.

Taxaceae Lindl. Yew Family.

41. *Taxus canadensis* Marsh. Ground Hemlock. Forms, with young Sugar Maples, the principal undergrowth of the hardwood forest, II. 2, IV. 3, VI.

Naiadaceae Lindl.

42. *Potamogeton natans* L. Common Floating Pond-weed. Occasional in Carp river, IV. 1, and forms a well defined zone in shallow water about the margin of Carp Lake, V. 1.

Alismaceae DC. Water-Plantain Family.

43. *Sagittaria sp.* Arrow-head. Near the margin of the water on the mud flats, IV. 1, and delta, V. 2, of Carp river.

Vallisneriaceae Dumort. Tape-grass Family.

44. *Vallisneria spiralis* L. Tape-grass. Forms extensive mats in the shallow water at the west end of Carp Lake, V. 1, and occasionally about the margin of Little Carp Lake, VII. 1.

Gramineae Juss. Grass Family.

45. *Panicum xanthophysum* A. Gray. Slender Panicum. In the rock crevices on the mountain top, III. 2, 5, 6.

46. *Cinna latifolia* (Trev.) Griseb. Occasional in the hardwood forest, II. 2, IV. 3, and along the banks of Carp creek, VI.

47. *Agrostis hyemalis* (Walt.) B. S. P. Rough Hair-grass. On the delta of Carp river, V. 2, and in the beaver meadow on Little Carp river, VII. 2.

48. *Calamagrostis canadensis* (Michx.) Beauv. Blue Joint-grass. In the cassandra zone, on the dryer parts of the mud flats, IV. 2, and delta V. 2, of Carp river, and in the beaver meadow on Little Carp river, VII. 2.

49. *Deschampsia flexuosa* (L.) Trin. Wavy Hair-grass. In the cassandra zone, IV. 2, and on the delta, V. 2, of Carp river; also in the beaver meadow, VII. 2, on Little Carp river.

50. *Panicularia canadensis* (Michx.) Kuntze. Rattlesnake-grass. Cassandra zone, IV. 2, and delta, V. 2, of Carp river; also in the beaver meadow, VII. 2, on Little Carp river.

Cyperaceae J. St. Hil. Sedge Family.

51. *Dulichium arundinaceum* (L.) Britton. Dulichium. Near the submerged margins of the mud flats and deltas of Carp and Little Carp rivers.

52. *Scirpus cyperinus* (L.) Kunth. Wool-grass. In the cassandra zone and on the mud flats, IV. 2, and delta, V. 2, of Carp river; and on the mud flats and beaver meadow along Little Carp river, VII. 2. Also along the bank of Carp creek, VI.

53. *Carex monile* Tuckerm. A prominent sedge in the beaver meadow on Little Carp river, VII. 2.

54. *Carex riparia* Curtis. In the cassandra zone and on the mud flats,

IV. 2, and delta, V. 2, of Carp river. Also about the shore of Carp Lake, V. 1.

55. *Carex filiformis* L. In the cassandra zone, on the mud flats, IV. 2, and delta, V. 2, of Carp river; and in the beaver meadow and on the mud flats on Little Carp river, VII. 2.

56. *Carex crinita* Lam. On the banks of Carp creek, VI.

57. *Carex viridula* Michx. In the cassandra zone and on the mud flats IV. 2, and delta, V. 2, of Carp river; and in the beaver meadow and on the mud flats of Little Carp river, VII. 2.

58. *Carex pubescens* Muhl. Along the banks of Carp Creek, VI.

Araceae Neck. Arum Family.

59. *Spathyema foetida* (L.) Raf. Skunk Cabbage. Occasional in the alder thickets along Carp river, IV. 2, and along the banks of Carp Creek, VI.

Eriocaulaceae Lindl. Pipewort Family.

60. *Eriocaulon septangulare* With. Seven-angled Pipewort. Common on the shores of Carp Lake, V. 1.

Juncaceae Vent. Rush Family.

61. *Juncus effusus* L. Bog Rush. Common on the mud flats, IV. 2, and delta V. 2, of Carp river. Also abundant in the beaver meadow and on the mud flats on Little Carp river, VII. 2.

62. *Juncus tenuis* Willd. In the beaver meadow and on the mud flats of Little Carp river, VII. 2.

63. *Juncus canadensis* J. Gay. Canada Rush. In shallow water about the margin of Carp Lake, V, and Little Carp Lake, VII. 1.

Convallariaceae Link. Lily-of-the-valley Family.

64. *Clintonia borealis* (Ait.) Raf. Yellow Clintonia. A very common form in the hardwood forests, II. 2, IV. 3, VI.

65. *Vagnera racemosa* (L.) Morong. Wild Spikenard. In the hardwood forest, II. 2, IV. 3, VI.

Iridaceae Lindl. Iris Family.

66. *Iris versicolor* L. Larger Blue Flag. On the mud flats and in the cassandra and alder thickets along Carp river, IV. 2; also in the beaver meadow on Little Carp river, VII. 2, and in the arbor vitae swamps, II. 1.

Orchidaceae Orchid Family.

67. *Gyrostachys cernua* (L.) Kuntze. Nodding Ladies Tresses. On the shores of Carp Lake, V. 1; on the delta, V. 2, and occasionally in the cassandra zones on Carp river, IV. 2. Also in the beaver meadow on Little Carp river VII. 2.

68. *Peramium pubescens* (Willd.) Mac M. Downy Rattlesnake Plantain. Generally distributed through the hardwood forest, II. 2, IV. 3, VI; also occurring in the tamarack swamp, IV. 4.

Salicaceae Lindl. Willow Family.

69. *Populus grandidentata* Michx. Large-toothed Aspen. In the hardwood forest bordering the beach of Lake Superior, I, the clearing, II. 2, and

mountain top, II. 5, III. 1 and 4. Also on the lower part of the talus slope, III, and in burnings.

70. *Populus tremuloides* Michx. American or Quaking Aspen. The principal form of the forest bordering open localities; adjoins the beach of Lake Superior, I, the clearing, II. 4, and the mountain top, II. 5, III. 1 and 4. Also conspicious on the lower part of the talus slopes, III, and in burnings, VI.

71. *Salix spp.* Willow. A number of willows occur in the alder and cassandra zones along Carp river, IV. 2; in the beaver meadow on Little Carp river, VII. 2, and in the aspen zone on the mountain top, II. 5.

Myricaceae Dumort. Bayberry Family.

72. *Myrica cerifera* L. Wax-myrtle. In the cassandra zone along Carp river, IV. 2.

Betulaceae Agardh. Birch Family.

73. *Ostrya virginiana* (Mill.) Willd. Iron-wood. Occasional in the hardwood forest, II. 2, IV. 3, VI.

74. *Corylus rostrata* Ait. Beaked Hazel-nut. In the woods on the lower part of the talus slopes, IV. 3; pushing out beyond the forest with the birches and often extending well up the slope, III.

75. *Betula papyrifera* Marsh. Paper or Canoe Birch. Throughout the climax forest, II. 2, IV. 3, VI. Also a prominent form on the lower part of the talus slopes, IV. 3.

76. *Betula lutea* Michx. Yellow Birch. Occasional through the forest II. 2, IV. 3, VI. More conspicious in the hemlock forests.

77. *Betula glandulosa* Michx. Glandular or Scrub Birch. Common about the margin of the beaver meadow, VII. 2; with *Alnus incana* and several willows encroaching on the meadow.

78. *Alnus alnobetula* (Ehrh.) K. Koch. Green or Mountain Alder. A few shrubs occur in the aspen zone bordering the mountain top, III. 5.

79. *Alnus incana* (L.) Willd. Speckled or Hoary Alder. Nearly always present along streams, forming dense thickets. Along Carp river, IV. 2, between the cassandra and coniferous zones on wide parts of the flood-plain, and between the river and the forest where the flood-plain is narrow. Where a cassandra zone is present, there is nearly always a narrow strip of alders along the natural levees, separating the cassandra zone from the river. Also common about Carp Lake, V. 1; Little Carp Lake, VII. 1, and the beaver meadow, VII. 2.

Fagaceae Drude. Beech Family.

80. *Quercus rubra* L. Red Oak. A prominent form in the aspen zone, II. 5, III. 1, 4, bordering the mountain top. Also on the fine material at the top of the talus slope and on the ledges on the cliff face, III.

81. *Quercus macrocarpa* Michx. Burr Oak. In the aspen zone, II. 5, bordering the mountain top.

Nymphaeaceae DC. Water-lily Family.

82. *Nymphaea advena* Soland. Large Yellow Pond Lily. Abundant in Carp river, IV. 1, and near the margin of Carp Lake, V. 3.

83. *Castalia odorata* (Dryand.) Woodv. and Wood. Sweet-scented White

Water Lily. Several specimens were found in Carp river, IV. 1, which was the only locality in which it was observed.

Ranunculaceae Juss. Crowfoot Family.

84. *Caltha palustris* L. Marsh-marigold. In the alder thickets along Carp river, IV. 2; also common on the banks of Carp creek, VI.

85. *Coptis trifolia* (L.) Salisb. Gold-thread. Common in the hardwood forest, II. 2, IV. 3, VI, and in the tamarack swamp, IV. 4.

Sarraceniaceae LaPyl. Pitcher-Plant Family.

86. *Sarracenia purpurea* L. Pitcher-plant. Found commonly in the peat bog, IV. 4, and on a Sphagnum growth in the beaver meadow, VII. 2. Not observed elsewhere.

Rosaceae B. Juss. Rose Family.

87. *Opulaster opulifolius* (L.) Kuntze. Eastern Ninebark. Upper Beach of Lake Superior, I; in the aspen zone bordering the mountain top, II. 5, and on the rocky bluff at the east end of Little Carp Lake, VII.

88. *Spiraea salicifolia* L. American Meadow-sweet. In the cassandra zone on Carp river, IV. 2, and about the margin of the beaver meadow on Little Carp river, VII. 2.

89. *Rubus parviflorus* Nutt. White-flowering Raspberry. In the aspen zone about the clearing, II. 4, and mountain top, II. 5; in the open woods near the top of the slope, II. 2, and in burnings, VI. Very common in exposed situations. Locally known as the Thimbleberry

90. *Rubus strigosus* Michx. Wild Red Raspberry. On the Upper Beach of Lake Superior, I; in the aspen zone about the clearing, II. 4, and on the mountain top, II. 5. Also at the foot of the talus slopes, III.

91. *Rubus nigrobaccus* Bailey. High Bush Blackberry. Frequent in the cassandra zone, IV. 2, especially near the margin of the alder thickets.

92. *Rubus hispidus* L. Running Swamp Blackberry. Common in the cassandra zone on Carp river, IV. 2, and in the beaver meadow, VII. 2.

93. *Comarum palustre* L. Marsh Cinquefoil. In the cassandra zone, IV. 2, and on the delta of Carp river, V. 2, and in the beaver meadow on Little Carp river, VII. 2.

94. *Dasiphora fruticosa* (L.) Rydb. In the cassandra zone, IV. 2, and on the delta, V. 2.

94a. *Potentilla argentea* L. Silvery Cinquefoil. In rock crevices on the Middle and Upper Beaches of Lake Superior, I.

95. *Sibbaldiopsis tridentata* (Soland.) Rydb. Common in the rock crevices on the mountain top and on the cliff face, and among the rocks on talus slopes, III.

Pomaceae L. Apple Family.

96. *Sorbus americana* Marsh. American Mountain Ash. Common on the Upper Beach of Lake Superior, I, and at the foot of the talus slopes, III. Also occurs on the rocky bluff at the east end of Little Carp Lake.

97. *Aronia nigra* (Willd.) Britton. Black Chokeberry. Occasional on the lower part of the talus slopes, III.

98. *Amelanchier canadensis* (L.) Medic. Juneberry. Common on the Upper Beach of Lake Superior, I; in the aspen zone bordering the mountain

top, II. 5, III. 1, 4; on the ledges of the cliff; at the bottom and top of the talus slopes, III, and in the tamarack swamp, IV. 4.

99. *Crataegus sp.* Thorn-apple. Occasional on the cliff face and on the fine material at the top of the talus slopes, III.

Drupaceae DC. Plum Family.

100. *Prunus pumila* L. Dwarf Cherry. On the Upper Beach of Lake Superior, I, and in burnings, VI.

101. *Prunus pennsylvanica* L. f. Wild Red Cherry. Common on the lower parts of the talus slopes and on the finer material at the top, III, Also occurs on the ledges of the cliff, III, and in burnings, VI.

Papilionaceae L. Pea Family.

102. *Lathyrus maritimus* (L.) Bigel. Beach Pea. Upper and Middle Beaches of Lake Superior, I.

103. *Lathyrus ochroleucus* Hook. Cream-colored Vetchling. Upper Beach of Lake Superior, I.

Anacardiaceae Lindl. Sumac Family.

104. *Rhus glabra* L. Scarlet Sumac. In the aspen zone about the clearing, II. 4, and mountain top, II. 5. Also scattered over the talus slopes, III.

105. *Rhus microcarpa* (Michx.) Steud. Northern Poison Oak. On the talus slopes and cliff face, III.

Aceraceae St. Hil. Maple Family.

106. *Acer saccharum* Marsh. Sugar or Rock Maple. The principal forest tree of the region, forming, with a small portion of Balsam Fir, Basswood and Hemlock, the climax forest of the region, II. 2, IV. 3, VI.

107. *Acer spicatum* Lam. Mountain Maple. Occurs as a scattered undergrowth in the hardwood forest, II. 2, IV. 3, VI; becoming more abundant in the open woods toward the talus slopes, III, mountain top, II. 5, and beach of Lake Superior, I.

Rhamnaceae Dumort. Buckthorn Family.

108. *Ceanothus americanus* L. New Jersey Tea. A prominent plant in the heath society on the mountain top, III. 2, 5, 6, and at the foot of the talus slope. Also occurs on the finer material at the top of the talus slope and on ledges of the cliff.

Vitaceae Lindl. Grape Family.

109. *Parthenocissus quinquefolia* (L.) Planch. Virginia Creeper. Occasional on the talus slopes and cliff face, III.

Tiliaceae Juss. Linden Family.

110. *Tilia americana* L. Basswood. Occasional in the hardwood forest, II. 2, IV. 3, VI.

Hypericaceae Lindl. St. Johns-wort Family.

111. *Hypericum ellipticum* Hook. Pale St. Johns-wort. On the delta, V. 2, and in the cassandra zone, IV. 2, on Carp river; and in the beaver meadow on Little Carp river, VII. 2.

Violaceae DC. Violet Family.

112. *Viola spp.* A number of species of violets occur in the forest, II, 2, IV. 3, VI., and in the alder thickets, IV. 2.

Eleagnaceae Lindl. Oleaster Family.

113. *Lepargyraea canadensis* (L.) Greene. Canadian Buffalo-berry. Upper Beach of Lake Superior, I.

Onagraceae Dumort. Evening-primrose Family.

114. *Chamaenerion angustifolium* (L.) Scop. Fire-weed. In the clearing, II. 3, at the foot of the talus slopes, III, and almost universally in burnings, VI.

115. *Onagra biennis* (L.) Scop. Common Evening-primrose. In the rock crevices on the mountain top, III. 2, 5, 6. Also on ledges on the cliff face.

Haloragidaceae Kl. and Garke. Water-milfoil Family.

116. *Myriophyllum sp.* Water-milfoil. The common aquatic plant in Carp river, IV. 1, Carp Lake, V. 3, and Little Carp Lake, VII. 1.

Araliaceae Vent. Ginseng Family.

117. *Aralia nudicaulis* L. Wild Sarsaparilla. Common throughout the forest, II. 2, IV. 3, VI.

Umbelliferae B. Juss. Carrot Family.

118. *Heracleum lanatum* Michx. Cow-parsnip. Common in the clearing, II. 3.

Cornaceae Link. Dogwood Family.

119. *Cornus canadensis* L. Low or Dwarf Cornel. Generally distributed, occurring in the hardwood forest, II. 2, VI; in the aspen zone, II. 5, and extending, to some extent, on the heath mat beyond the aspen zone on the mountain top, III. 2, 3, 5, 6. Also common in the tamarack swamp, IV. 4.

120. *Cornus circinata* L'Her. Round-leaved Dogwood. Common in the aspen zone, II. 5, about the mountain top; and at the bottom and top of the talus slopes, III.

121. *Cornus stolonifera* Michx. Red-osier Dogwood. Quite common in the alder zone along Carp river, IV. 2, Carp Lake V. 1, Little Carp Lake, VII. 1, and in the beaver meadow on Little Carp river, VII. 2.

Pyrolaceae Agardth. Wintergreen Family.

122. *Chimaphila umbellata* (L.) Nutt. Pipsissewa. Prince's Pine. Occasionally in the hardwood forest, II. 2, and in the pine zone, III. 3.

Monotropaceae Lindl. Indian-pipe Family.

123. *Monotropa uniflora* L. Indian-pipe. In damp shady places in the climax forest, II. 2, IV. 3, VI.

Ericaceae DC. Heath Family.

124. *Ledum groenlandicum* OEder. Labrador Tea. Common in the tamarack swamp, IV. 4.

125. *Chamaedaphne calyculata* (L.) Moench. Dwarf Cassandra. Forming dense thickets in the wider parts of the flood-plain of Carp river, IV. 2. Also present, but not forming extensive thickets, about the beaver meadow on Little Carp river, VII. 2.

126. *Epigaea repens* L. Trailing Arbutus. Occasionally seen in the pine zone on the mountain top, III. 3.

127. *Gaultheria procumbens* L. Creeping Wintergreen. A common plant in the undergrowth of the aspen zone, II. 5, III. 1 and 4, and in the heath mats on the bald areas, III. 2, 5, 6.

128. *Arctostaphylos uva-ursi* (L.) Spreng. Red Bearberry. The principal heath plant in the aspen zone, II. 5, III. 1, 4, and in the mats on the mountain top, III. 2, 5, 6. Also occurs on ledges of the cliff, at the bottom and top of the talus slopes, III, and on the Upper Beach of Lake Superior, I.

Vacciniaceae Lindl. Huckleberry Family.

129. *Vaccinium uliginosum* L. Great Bilberry. Upper Beach of Lake Superior, I, and in the aspen zone on the mountain top, II. 5.

130. *Vaccinium canadense* Richards. Canada Blueberry. In a moist ravine through the hardwood forest in the valley of Carp river, IV. 3, and in the tamarack swamp, IV. 4.

131. *Vaccinium pennsylvanicum* Lam. Dwarf or Low-bush Blueberry. A prominent form in the undergrowth of the aspen zone surrounding the mountain top, II. 5, and in the heath mat on the bald areas, III. 2, 5, 6. Also on ledges on the cliff face, at the top and bottom of the talus slopes, III, and on the Upper Beach of Lake Superior, I.

132. *Vaccinium nigrum* (Wood) Britton. Low Black Blueberry. Associated with *V. pennsylvanicum* in the aspen zone on the mountain top, II. 5, III. 1, 4; on the bare top, III. 2, 5, 6; on ledges on the cliff face, and on the talus slopes, III.

132. *Chiogenes hispidula* (L.) T. and G. Creeping Snowberry. Common in the tamarack swamp, IV. 4.

Oleaceae Lindl. Olive Family.

134. *Fraxinus americana* L. White Ash. Occasional in the tamarack swamp, IV. 4; with the conifers and alders in broad portions of the flood plain of Carp river, IV. 2, and about the beaver meadow, VII. 2.

135. *Fraxinus nigra* Marsh. Black Ash. Associated with *F. americana*.

Asclepiadaceae Lindl. Milkweed Family.

136. *Asclepias incarnata* L. Swamp Milkweed. Occasional in the cassandra zone, IV. 2, and on the delta, V. 2, of Carp river. Also in the beaver meadow on Little Carp river, VII. 2.

Labiatae B. Juss. Mint Family.

137. *Scutellaria sp.* Skullcap. An unidentified species of this genus occurs commonly in the alder thickets along Carp river, IV. 2, and along Carp creek, VI.

Scrophulariaceae Lindl. Figwort Family.

138. *Melampyrum lineare* Lam. Narrow-leaved Cow-wheat. In the aspen zone bordering the mountain top, II. 5, III. 1, 4.

Lentibulariaceae Lindl. Bladderwort Family.

139. *Utricularia cornuta* Michx. Horned Bladderwort. On the beach of Carp Lake, V. 1.

Rubiaceae B. Juss. Madder Family.

140. *Galium triflorum* Michx. Sweet-scented or Fragrant Bedstraw. Common in the more open woods near the top of the first ridge, II. 2.

Caprifoliaceae Vent. Honeysuckle Family.

141. *Viburnum opulus* L. High Bush-cranberry. Along the banks of Carp river, IV. 2, and about the shores of Little Carp Lake, VII. 1.

142. *Viburnum pauciflorum* Pylaie. Few-flowered Cranberry-tree. On Carp river in the cassandra zone, IV. 2, and tamarack swamp, IV. 4; also about the shores of Little Carp Lake, VII. 1.

143. *Linnaea americana* Forbes. American Twin-flower. Of general distribution throughout the hardwood forest, II. 2, IV. 3, VI; becoming more abundant toward the top of the slopes and in the aspen zone bordering the mountain top, II. 5.

144. *Symphoricarpos pauciflorus* (Robbins) Britton. Low Snowberry. In the aspen zone bordering the mountain top, II. 5, III. 1, 4.

145. *Lonicera oblongifolia* (Goldie) Hook. Swamp Fly-Honeysuckle. In the shrub zone of the tamarack swamp, IV. 4.

146. *Lonicera ciliata* Muhl. American Fly Honeysuckle. In the hardwood forest, II. 2, and VI.

147. *Diervilla diervilla* (L.) Mac M. Bush Honeysuckle. Common in the aspen zone bordering the clearing, II. 4, and mountain top, II. 5, III. 1, 4. Also occurs on the lower part of the talus slopes, III.

Campanulaceae Juss. Bell-flower Family.

148. *Campanula rotundifolia* L. Harebell. In the rock crevices of the Middle and Upper Beaches of Lake Superior, I, and mountain top, III. 2, 5, 6. Occasional on ledges of the cliff and on the talus slopes, III.

149. *Campanula aparinoides* Pursh. Marsh Bellflower. In the cassandra zone, IV. 2, and on the delta, V. 2, of Carp river; and in the beaver meadow on Little Carp river, VII. 2.

150. *Lobelia spicata* Lam. Pale Spiked Lobelia. In the rock crevices of the Middle Beach, and on the thin soil on the Upper Beach of Lake Superior, I.

Compositae Adans. Thistle Family.

151. *Eupatorium purpureum* L. Joe-pye-weed. In the cassandra zone IV. 2, and on the delta, V. 2, of Carp river; and in the beaver meadow on Little Carp river, VII. 2.

152. *Solidago bicolor* L. White Goldenrod. In the rock crevices and on the thin soil of the mountain top, III. 2, 5, 6.

153. *Solidago erecta* Pursh. Slender Goldenrod. In the crevices on the bare mountain top, III. 2, 5, 6. The specimens collected, according to Dr. C. A. Davis, are not typical but are nearest to this form.

154. *Solidago uliginosa* Nutt. Bog Goldenrod. Common in the cassandra zone, IV. 2, and on the delta, V. 2, of Carp river, and in the beaver meadow of Little Carp river, VII. 2.

155. *Solidago neglecta* T. and G. Swamp Goldenrod. Middle and Upper Beaches of Lake Superior, I, and in the beaver meadow on Little Carp river, VII. 2.

156. *Solidago juncea* Ait. Early or Sharp-toothed Goldenrod. Common in the aspen zone, II. 5, and on the bare mountain top, III. 1, 2, 4, 5, 6.

157. *Euthamia graminifolia* (L.) Nutt. Associated with *S. juncea*, II. 5, III. 1, 2, 4, 5, 6.

158. *Aster divaricatus* L. White Wood Aster. Apparently of general distribution in the hardwood forest, II. 2, IV. 3, VI.

159. *Aster macrophyllus* L. Large-leaved Aster. Occasional in damp shady woods, II. 2, IV. 3, VI.

160. *Artemisia caudata* Michx. Tall or Wild Wormwood. Occasional in the aspen zone surrounding the mountain top, II. 5, III. 1, 4.

2. ISLE ROYALE.

Polypodiaceae R. Br. Fern Family.

1. *Polypodium vulgare* L. In the rock crevices on the end of the Minong Trap Range, IX, and in the rock crevices and on the shingle beach at Siskowit Bay, VIII.

2. *Adiantum pedatum* L. Maiden-hair Fern. Occasional in the Balsam Fir and Spruce woods, VI.

3. *Pteridium aquilinum* (L.) Kuhn. Brake. In the coniferous forest on the north side of the Greenstone Range near the shore of Lake Desor. Also about the margin of the clearing, I.

4. *Phegopteris phegopteris* (L.) Underw. On the shores of Siskowit Bay, VIII.

Equisetaceae Michx. Horsetail Family.

5. *Equisetum arvense* L. On the shore of Siskowit Bay, VIII, and on the shores of the islands in Lake Desor, VII.

Lycopodiaceae Michx. Club-moss Family.

6. *Lycopodium obscurum* L. Ground Pine. In the tamarack and spruce woods in the valley of Washington river, II.

7. *Lycopodium annotinum* L. On the beach at Grace Harbor; with the heaths on the Minong Trap Range, IX, and in the coniferous forest, VI.

8. *Lycopodium clavatum* L. Running Pine. In the coniferous and deciduous forests, VI, and III; on the beach at Grace Harbor, and on the Minong Trap promontory, IX.

9. *Lycopodium complanatum* L. In the alder thickets along Washington river, II. and with the heaths on the Minong Trap promontory, IX.

Isoetaceae Underw. Quillwort Family.

10. *Isoetes sp.* Among the rocks in shallow water about the islands in Lake Desor, VII.

Pinaceae Lindl. Pine Family.

11. *Pinus strobus* L. White Pine. Large isolated trees occur scattered through the forest, III, and VI. Young trees occur on the jutting promontories on the southwestern end of the island, IX. A few trees also occur with *P. resinosa* on a small strip of rock beach on the north shore of Lake Desor, VII.

12. *Pinus resinosa* Ait. Norway or Red Pine. Large trees occur occasionally in the coniferous forest on exposed slopes, VI. A few trees were also found on the rocky promontory, IX, and with *P. strobus* on a small strip of exposed beach on the north shore of Lake Desor, VII.

13. *Larix laricina* (Du Roi) Koch. Tamarack. Occurs along the flood-plains of the streams, where the valleys are broad, II, IV. It becomes more abundant in bogs, forming a nearly pure stand, V. Also occurs occasionally in the old beach pools on the Minong Trap promontory, IX.

14. *Picea canadensis* (Mill.) B. S. P. White Spruce. Generally distributed. It occurs with the Tamarack and Black Spruce on the flood-plains, II, IV, and forms an important part of the coniferous forest of the slopes, VI, but becomes less abundant toward the top of the higher ridges, III. With the Balsam Fir and Paper Birch, it succeeds the heaths and Arbor Vitae on the rocky promontories, IX.

15. *Picea mariana* (Mill.) B. S. P. Black Spruce. This tree is associated with the Tamarack and White Spruce on the flood-plains of the streams, II, IV. It also occurs occasionally in the old pools on the Minong Trap promontory, IX.

16. *Abies balsamea* (L.) Mill. Balsam Fir. This tree is generally distributed, occurring in the river valleys, II, IV, and on the ridges, III, VI. It apparently forms, with the White and Yellow Birch and White Spruce, the principle forest of the island.

17. *Thuja occidentalis* L. White Cedar. Arbor Vitae. This tree is most abundant in the valleys along streams, IV, where it occasionally forms dense growths. It is also found, however, on the shores of Lake Desor, VII, and about Washington Harbor, X; while on the Minong Trap promontory, IX, it is the first tree to gain a foothold, and may be seen growing in the crevices, nearly prostrate on the rock.

18. *Juniperus nana* Willd. Low Juniper. Common on the rock surfaces. of the Minong Trap promontory, IX.

Taxaceae Lindl. Yew Family.

19. *Taxus canadensis* Marsh. Ground Hemlock. This is one of the most characteristic forms of the Isle Royale forest. It forms a dense and almost impenetrable undergrowth throughout the coniferous woods, VI, but it is not as abundant in the flood-plain societies, II, IV. In the bogs it may be nearly or entirely wanting, and in the deciduous forest along the top of the Greenstone Range, III, it is often replaced over small areas by *Corylus rostrata.*

Sparganiaceae Agardh. Bur-reed Family.

20. *Sparganium eurycarpum* Engelm. In the margin of Washington river near its mouth, II, and about the shores of Lake Desor, VII.

Gramineae Juss. Grass Family.

21. *Phragmites phragmites* (L.) Karst. Reed. Along the margin of Washington river near its mouth, II, and about the shores of Lake Desor, VII.

Cyperaceae J. St. Hil. Sedge Family.

22. *Carex intumescens* Rudge. Along Washington river, II.
23. *Carex retrorsa* Schwein. Along Washington river, II.
24. *Carex trisperma* Dewey. Along Washington river, II.
25. *Carex tribuloides* Wahl. Along Washington river, II.

Araceae Neck. Arum Family.

26. *Spathyema foetida* (L.) Raf. Skunk Cabbage. In alder thickets, along Washington river, II, and Washington creek, IV.

Juncaceae Vent. Rush Family.

27. *Juncus effusus* L. Soft or Bog Rush. Along the shore of Washington river, II.

Convallariaceae Link. Lily-of-the-Valley Family.

28. *Clintonia borealis* (Ait.) Raf. In the forests on the flood-plain of Washington river, II, and on the adjacent ridges, III, VI.
29. *Vagnera racemosa* (L.) Morong. Wild Spikenard. In the alder thicket near the mouth of Washington creek, IV.
30. *Vagnera trifolia* (L.) Morong. Three-leaved Solomon's Seal. Found commonly in the alder thickets along Washington river, II, and Washington creek, IV.
31. *Streptopus amplexifolius* (L.) DC. In the alder thicket along Washington creek, IV.
32. *Salomonia biflora* (Walt.) Britton. Hairy Solomon's Seal. In moist places in the coniferous forest, VI.

Iridaceae Lindl. Iris Family.

33. *Iris versicolor* L. Large Blue Flag. In low places about the shores of Lake Desor and on the smaller islands, VII.

Orchidaceae Lindl. Orchid Family.

34. *Listera convallarioides* (Sw.) Torr. On the shores of Siskowit Bay, VIII, and Grace Harbor.
35. *Peramium pubescens* (Willd.) MacM. Downy Rattlesnake Plantain. Common in the coniferous forest, VI.

Salicaceae Lindl. Willow Family.

36. *Populus grandidentata* Michx. Large-toothed Aspen. In burnings and on the margin of clearings. Found in the large clearings at Siskowit

Bay, VIII, and Washington Harbor, I; and on the cliffs along the northwest shore of the island.

37. *Populus tremuloides* Michx. American Aspen. This tree occurs in the same conditions as *P. grandidentata* but is more abundant. It was abundant in the burnings and clearings at Siskowit Bay, VIII, and Washington Harbor, I. It also occurs on the rocky promontories at the southwest end of the island, IX, on the cliffs along the northwest shore of the Isle, and on the smaller islands in Lake Desor, VII. It prefers dry open habitats and is one of the first trees to encroach on the clearings.

38. *Salix spp.* Willow. Several undetermined willows occur in the alder zone along the streams, II, IV, and about Lake Desor, VII.

Betulaceae Agardh. Birch Family.

39. *Corylus rostrata* Ait. Beaked Hazel-nut. As underbrush through the forest, III, VI, with the Ground Hemlock. Often forming in small areas a nearly pure stand.

40. *Betula papyrifera* Marsh. Paper or Canoe Birch. Of general distribution, being a prominent form in the coniferous and deciduous forests, although it predominates in neither. It is the chief deciduous tree on this part of the island, owing to its general distribution.

41. *Betula lutea* Michx. f. Yellow Birch. This birch is of general distribution in the forests of the slopes, VI, and river valleys, II, but is apparently more abundant in the former.

42. *Alnus incana* (L.) Willd. Speckled or Hoary Alder. Forms extensive thickets along the streams, II, IV, about the shores of the Isle, and on low ground around Lake Desor, VII.

Santalaceae R. Br. Sandalwood Family.

43. *Comandra livida* Richards. Recorded by Mr. Macduff as occurring in an alder thicket near the mouth of Grace creek.

Nyphaeaceae DC. Water Lily Family.

44. *Castalia odorata* (Dryand) Woodv. and Wood. Sweet-scented White Water Lily. In a small shallow bay at the west end of Lake Desor, VII. The only place observed.

Ranunculaceae Juss. Crowfoot Family.

45. *Caltha palustris* L. Marsh-marigold. This species seemed to be characteristic of the alder thickets, II, IV.

46. *Coptis trifolia* (L.) Salisb. Gold-thread. Of general distribution in the river valleys, II, IV, and V, and on the slopes, III and VI.

Saxifragaceae Dumort. Saxifrage Family.

47. *Mitella nuda* L. Occasional in the Tamarack and Spruce forests along Washington river, II, and in the Balsam and Spruce forests of the slopes, VI.

Rosaceae B. Juss. Rose Family.

48. *Opulaster opulifolius* (L.) Kuntze. Eastern Ninebark. About the shores of Siskowit Bay, VIII; on the Minong Trap promontory, IX, and about the shores of the islands in Lake Desor, VII.

49. *Spiraea salicifolia* L. Willow-leaved or American Meadow-sweet. This shrub was found along Washington river, II, between the alder and sedge zones, where the latter was well developed.

50. *Rubus parviflorus* Nutt. White-flowering Raspberry. In sunny spots in the woods, III, VI, also along the shore of Washington Harbor, X.

51. *Rubus arcticus* L. Arctic Raspberry. In the bogs, IV, and V. Apparently not common.

52. *Rubus strigosus* Michx. Wild Red Raspberry. In burnings and clearings, Siskowit Bay, VIII, and at Washington Harbor, I.

53. *Potentilla argentea* L. Silvery or Hoary Cinquefoil. On the shingle beach at Siskowit Bay, VIII.

54. *Sibbaldiopsis tridentata* (Soland.) Rydb. Three-toothed Cinquefoil. On the shingle beach and in the rock crevices at Siskowit Bay, VIII, and in the rock crevices on the Minong Trap promontory, IX.

55. *Dasiphora fruticosa* (L.) Rydb. Shrubby Cinquefoil. In the rock crevices on the Minong Trap promontory, IX.

Pomaceae L. Apple Family.

56. *Sorbus americana* Marsh. American Mountain Ash. In rocky exposed situations, especially about the shores of the island and on the islands in Lake Desor, VII.

57. *Amelanchier canadensis* (L.) Medic. June-berry. On the shore at Siskowit Bay, VIII, and Grace Harbor; also in burnings and clearings, and on the small islands in Lake Desor, VII.

Drupaceae DC. Plum Family.

58. *Prunus pumila* L. Sand Cherry. In the clearing at Siskowit Bay, VIII, and on the rocky bluffs along the northwest shore of the island.

59. *Prunus pennsylvanica* L. f. Wild Red Cherry. On the islands in Lake Desor, VII.

Papilionaceae L. Pea Family.

60. *Lathyrus maritimus* (L.) Bigel. Beach Pea. On shingle beaches in the bays on the southwest end of the island (Macduff).

61. *Lathyrus ochroleucus* Hook. Cream-colored Vetchling. As the last.

62. *Empetrum nigrum* L. Black Cranberry. With the heaths on thin soil on the Minong Trap promontory, IX.

Aceraceae St. Hil. Maple Family.

63. *Acer saccharum* Marsh. Sugar or Rock Maple. Only found on the top of the Greenstone Range, III, where it predominates in a narrow strip along the crest of the ridge. This is the only hardwood forest on the south end of the island, and it is reported by Mr. Hollinger to extend the length of the island.

64. *Acer spicatum* Lam. Mountain Maple. This shrub is generally distributed as undergrowth in the forest, III, VI, with *Taxus canadensis* and *Corylus rostrata*. Although more abundant than the latter, it does not form as large a proportion of the undergrowth as the former.

Rhamnaceae Dumort. Buckthorn Family.

65. *Rhamnus alnifolia* L'Her. In the alder thickets, II, IV.

66. *Ceanothus americanus* L. New Jersey Tea. With the heaths on the Minong Trap promontory, IX.

Violaceae DC. Violet Family.

67. *Viola spp.* Violet. A number of species of violets were observed in the woods and alder thickets, but, as they were not in bloom, they were not identified with certainty.

Haloragidaceae Kl. and Garcke. Water-milfoil Family.

68. *Myriophyllum sp.* An unidentified species was abundant in Washington river near the mouth, II.

Araliaceae Vent. Ginseng Family.

69. *Aralia nudicaulis* L. Wild Sarsaparilla. Generally distributed throughout the forests of the slope, III, VI, and river valleys, II, IV.

Cornaceae Link. Dogwood Family.

70. *Cornus canadensis* L. Dwarf Cornel. Generally distributed through the forests of the slopes, III, VI, and in the forest of the river valleys, II, IV, V. It also occurs with the heaths on the Minong Trap promontory, IX.

71. *Cornus stolonifera* Michx. Red-osier Dogwood. Occasional in the tamarack-spruce forests of the river bottoms, II, IV, V. Also about the shore of Lake Desor, VII.

Pyrolaceae Agardh. Wintergreen Family.

72. *Chimaphila umbellata* (L.) Nutt. Pipsissewa. Prince's Pine. In damp woods, III, and VI.

Monotropaceae Lindl. Indian-pipe Family.

73. *Monotropa uniflora* L. Indian-pipe. Occasional in shady situations in the forest, III, VI, and in the tamarack and spruce woods in the river valleys, II, IV and V.

Ericacae DC. Heath Family.

74. *Ledum groenlandicum* OEder. Labrador Tea. In the tamarack-spruce forest, on the flood-plain of Washington river, II, and on the Sphagnum in old pools on the Minong Trap promontory, IX.

75. *Andromeda polifolia* L. Wild Rosemary. In the tamarack and spruce woods on the flood-plain of Washington river, II.

76. *Chamaedaphne calyculata* (L.) Moench. Dwarf Cassandra. On the Sphagnum growth in old rock pools on the Minong Trap promontory, IX.

77. *Arctostaphylos uva-ursi* (L.) Spreng. Red Bearberry. On the thin soil on the outer end of the Minong Trap promontory, IX. With the other heaths, it follows the crevice grasses and sedges.

Vacciniaceae Lindl. Huckleberry Family.

78. *Vaccinium pennsylvanicum* Lam. Dwarf or Low-bush Blueberry. Distribution as the last.

79. *Chiogenes hispidula* (L.) T. and G. Creeping Snow-berry. Common in the low tamarack-spruce woods along Washington river, II, and Washington creek, IV. Also in low spots in the slope forest, VI, and tamarack swamp, V.

Oleaceae Lindl. Olive Family.

80. *Fraxinus nigra* Marsh. Black Ash. Occasional in the tamarack and spruce woods on the flood-plain of Washington river, II, and in the bog, V.

Asclepiadaceae Lindl. Milkweed Family.

81. *Asclepias incarnata* L. Swamp Milkweed. Occasional in the grass and sedge zone along Washington river near its mouth, II.

Caprifoliaceae Vent. Honeysuckle Family.

82. *Viburnum opulus* L. High Bush-cranberry. In the tamarack and spruce woods, II, and about the shores of the islands in Lake Desor, VII.

83. *Viburnum pauciflorum* Pylaie. Few-flowered Cranberry-tree. In a bog near the mouth of Grace creek (Macduff).

84. *Linnaea americana* Forbes. American Twin-flower. Of general distribution throughout the forest, II, III, VI.

85. *Lonicera oblongifolia* (Goldie) Hook. Swamp Fly-honeysuckle. In the slope forest, VI, (Macduff).

86. *Lonicera ciliata* Muhl. American Fly-honeysuckle. Occasional in the slope forests, VI, (Macduff).

87. *Diervilla diervilla* (L.) MacM. Bush Honeysuckle. In the clearings at Siskowit Bay, VIII, and Washington Harbor, I.

Campanulaceae Juss. Bell-flower Family.

88. *Campanula rotundifolia* L. Harebell. In the rock crevices on the Minong Trap promontory, IX, and in the rock crevices and on the shingle beach at Siskowit Bay, VIII.

89. *Lobelia spicata* Lam. Pale Spiked Lobelia. In the rock crevices on the Minong Trap promontory, IX.

Compositae Adans. Thistle Family.

90. *Eupatorium purpureum* L. Joe-Pye-Weed. Among the sedges along Washington river, II. Also on the Sphagnum in the abandoned rock pools, IX.

91. *Euthamia graminifolia* (L.) Nutt. Bushy or Fragrant Goldenrod. On the shores of Siskowit Bay, VIII, and in the rock crevices on the Minong Trap promontory, IX.

ANNOTATED LIST OF THE MOLLUSCS OF THE PORCUPINE MOUNTAINS AND ISLE ROYALE, MICHIGAN.

BRYANT WALKER AND A. G. RUTHVEN.

This list has been prepared from the collections and field notes made by A. G. Ruthven. The species of *Pisidium, Sphaerium* and *Vertigo* were identified by Dr. V. Sterki, the Slugs by Dr. H. A. Pilsbry, and the remainder of the collection by Bryant Walker.

1. PORCUPINE MOUNTAINS.

1. *Agriolimax campestris* (Binn.). This species was found among the fallen leaves in the hardwood forest, II. 2, and under a pine log in the aspen zone on the mountain top, III. 1.

2. *Pallifera hemphilli* (W. G. Binn.). As represented by the collections, this slug is quite generally distributed. It was found among the fallen leaves in the deciduous forest, II. 2; beneath a fallen pine log in the pine zone, III. 1, and under the bark of a tamarack log, IV. 4.

3. *Zonitoides arborea* (Say). III. 1. A number of specimens of this species were taken under fallen pine trees among the bearberry and huckleberry bushes in the aspen zone. IV. 4. Several specimens were found beneath the bark of decaying tamarack and cedar logs in the tamarack swamp. VI. A few specimens were taken in the moist humus about the roots of ferns on the bank of Carp creek, and among the moist decaying leaves on higher ground.

4. *Zonitoides milium* (Mse.). III. 2. Individuals of this species were collected in the dry earth about the roots of the New Jersey tea on the mountain top; in the humus about the roots of an arbor vitae in the cedar swamp, II. 1, and in the humus in the hemlock woods, II. 2.

5. *Zonitoides exigua* (Stimp.). II. 2. A number of individuals were found among the fallen leaves in the hemlock and maple woods. Several were also found in decaying cedar and tamarack logs in the tamarack swamp, IV. 4.

6. *Vitrea ferrea* (Mse.). IV. 4. A few individuals of this species were taken in a fallen tamarack log in the peat bog.

7. *Vitrea indentata* (Say). II. 2. Under dead moist leaves in the hardwood forest. III. 1. Under fallen logs and in the soil in the aspen zone on the mountain top. III. 2. In the dry earth in crevices and held by the roots of the heath plants on the bare mountain top, and among the roots of the New Jersey tea in the aspen zone, III. 4. Also found under the bark of fallen tamarack logs in the tamarack swamp, IV. 4.

8. *Vitrea multidentata* (Binn.). III. 1. Several specimens were taken under the bark of a fallen pine in the aspen zone at the top of the first range.

9. *Pyramidula alternata* (Say). II. 3. Specimens of this form were found crawling about on a log in the clearing, early in the morning while the dew was heavy.

10. *Pyramidula striatella catskillensis* Pils. This species was collected

among the damp leaves in the woods toward the bottom of the slope, II. 2, and near the top under fallen pine logs among the heath plants, III. 1. It was also found in the tamarack swamp, IV. 4, in decaying arbor vitae and tamarack logs.

11. *Pyramidula asteriscus* (Mse.). IV. 4. Two were found beneath the bark of fallen tamarack trees in the peat bog. This is the only station at which this species was taken.

12. *Helicodiscus lineatus* (Say). Among the damp fallen leaves in the hardwoods, II. 2; near the bottom of the slope, III. 1; in fallen tamarack logs in the tamarack swamp, IV. 4; in the damp humus about the roots of ferns on the banks of Carp creek, VI. This species seems to prefer a damp habitat, and the dead shells found in the crevices of the cliff face and among the talus blocks were probably blown there.

13. *Acanthinula harpa* (Say). III. 2. A number of specimens were collected in the dry soil held by the grasses and heath plants on the mountain top. This is one of the characteristic molluscs of this exceedingly dry and exposed habitat.

14. *Punctum pygmaeum* (Drap.). II. 1. A few specimens were collected in the damp humus among the roots of an arbor vitae in the swamp. II. 2. Found to occur quite abundantly among damp leaves in the hardwood forest. III. 1. A few individuals were found under fallen logs among the huckleberry bushes in the aspen zone. III. 2. Several taken in the dry earth about the roots of New Jersey tea on the mountain top. IV. 4. A few found beneath the bark of fallen tamarack trees in the peat bog.

15. *Sphyradium edentulum* (Drap.). II. 2. Among the damp leaves in the hardwood forest; also found under fallen pine trees in the aspen zone, III. 1, and in decaying tamarack and arbor vitae logs in the tamarack swamp, IV. 4.

16. *Polygyra albolabris* (Say). III. 1. Several specimens were taken beneath fallen logs in the aspen zone on the mountain top, and among the damp leaves in the hardwood forest, VI.

17. *Polygyra sp.* [young, probably *albolabris* (Say)]. III. 2. In the dry earth about the roots of the bearberry on the mountain top.

18. *Polygyra fraterna* (Say). II. 3. On a log in the clearing after a heavy dew. VI. Among the damp leaves in the forest.

19. *Strobilops virgo* (Pils.). Found in the damp leaves of the hardwood forest near the bottom of the slope, II. 2; under logs in the aspen zone near the top, III. 1; in the dry earth among the roots of the heath plants on the mountain top, III. 2, and among the roots of the blueberry in the aspen zone, III. 4. It was also found in decaying tamarack logs in the tamarack swamp, IV. 4; a few in the humus beneath a hemlock on II. 2, and in the moist loam about the roots of ferns on the banks of Carp creek, VI.

20. *Bifidaria curvidens* (Gld.). This species was taken under logs in the aspen zone on the mountain top, III. 1, and on the bald areas, III. 2, in the dry earth held by the heath plants.

20a. *Vertigo gouldii* Binn. Taken in the Porcupine Mountains, and at Limestone Mountain in the summer of 1903. These specimens have only recently been identified and with the following species constitute the forms listed in the 1903 list as *Vertigo sp.* (Sixth Report Mich. Acad. Sci. 1904, p. 190).

20b. *Vertigo ventricosa elatior* Sterki. See 20a.

21. *Cochlicopa lubrica morseana* (Doh.). This species was only found in damp leaves in the hardwood forest, II. 2, and in the moist humus on the banks of Carp creek, VI.

22. *Euconulus chersinus polygyratus* (Pils.). II. 2. Among the damp leaves in the hardwood forest. III. 1. Under fallen logs in the aspen zone about the mountain top. III. 2. In the dry soil in rock crevices and among grass roots near the brink of the precipice. VI. In the loam on the bank of Carp creek.

23. *Succinea avara* Say. III. 2. A few shells were found in crevices in the rock on the brink of the cliff. These specimens were probably blown here as the animal is said to prefer a damp habitat.

24. *Carychium exile* H. C. Lea. II. 2. Several individuals of this form were taken in a very moist place among fallen leaves in the hardwood forest. Also found in very wet humus about the roots of ferns on the banks of Carp creek, VI.

25. *Limnaea decollata* Migh. Occurs quite frequently in the rock pools of the Middle Beach, and behind projecting outcrops on the Lower Beach of Lake Superior, I, where they were protected from the full force of the waves.

26. *Limnaea desidiosa* Say. I. Occurs quite numerously in the rock pools of the Middle Beach, and has been dredged in Lake Superior at a depth of 8 to 13 fathoms (Baker).

27. *Physa sp.* (too young to identify). IV. 1. Found on the under side of lily pads in Carp river.

28. *Physa sayii?* Tapp. (young specimen). VI. Found in very damp leaves on the bank of Carp creek.

29. *Physa ancillaria* Say. *var.* I. In the rock pools of the Middle Beach of Lake Superior.

30. *Planorbis campanulatus* Say. Taken on the under side of lily pads and among the leaves of submerged water plants on Carp river, IV. 1, and on the larger stones forming the bottom near the shore of Carp Lake, V. 1.

31. *Planorbis bicarinatus striatus* Baker. V. 1. Found on the stones composing a strip of shingle beach on Carp Lake.

32. *Planorbis exacuous* Say. IV. 1. Taken on the under side of water lily leaves in Carp river.

33. *Planorbis parvus* Say. I. This species was found in several of the pools on the Middle Beach of Lake Superior, both on the bare rock and in the slight algal growth that lines the sides. It was also found among the leaves in the bottom of a pool formed by a spring in the forest, II. 2, and in considerable abundance on the under side of the larger rocks that lie loosely in the bed of Carp creek, VI. Dredged in Lake Superior at a depth of 8-13 fathoms (Baker).

34. *Planorbis deflectus?* Say. (immature). V. 1. Found on the small stones forming the bottom of Carp Lake just off shore. VII. 3. On the submerged sticks of a beaver dam on Little Carp river.

35. *Planorbis hirsutus* Gld. IV. 1. Among the leaves of a submerged aquatic plant in Carp river, about two feet below the surface of the water.

36. *Ancylus parallelus* Hald. IV. 1. On the stems and under side of lily pads in Carp river.

37. *Valvata tricarinata* (Say). V. 3. Among the leaves of submerged aquatic plants in Carp Lake.

38. *Amnicola limosa* (Say). IV. 1. Abundant on the stems and under side of lily pads, and among the leaves of submerged aquatics in Carp river. Also common on the stems and among the leaves of submerged aquatic plants in Carp Lake, V. 3.

39. *Anodonta marginata* Say. V. 1. Occurs quite numerously in Carp Lake, just off shore on a bottom of either silt or pebbles, and in considerable

numbers among the rushes on the delta of Little Carp river, VII. 1. VII. 3. One specimen was also taken on a mud flat in Little Carp river, near the lake.

40. *Sphaerium simile* (Say). V. 1. This species was found in the mud at the outlet of Carp Lake, and on the mud flats of Little Carp river, VII. 3.

41. *Sphaerium rhomboideum* (Say). V. 1. Partially buried in the fine silt covering the bottom of Carp Lake just off shore.

42. *Pisidium sp.* V. 2. Beneath a partly submerged log on the delta of Carp river.

43. *Pisidium sp.* (immature). II. 2. Among the leaves in a spring pool in the hardwood forest.

2. ISLE ROYALE.

1. *Agriolimax campestris* (Binn.). Among fallen alder leaves on a wet flat along Washington river, II, and in the humus of the cedar swamp, IV.

2. *Agriolimax*? (specimen mutilated). VIII. One specimen taken on the under side of a stone in shallow water at Siskowit Bay.

3. *Pallifera hemphilli* (W. G. Binn.). IV. A specimen of this slug was found in swamp humus on Washington creek.

4. *Vitrina limpida* Gld. VI. Several specimens were taken in decaying spruce logs in the coniferous forest. Found also in the damp fallen leaves, in the deciduous forest, III.

5. *Zonitoides arborea* (Say). II. On Washington river among the fallen leaves in an alder thicket on a wet mud flat, and among the leaves and under the bark of fallen spruce and birch trees on dryer ground. III. Found among the leaves and under the rocks in the deciduous forest. IV. A few specimens taken in the humus of a cedar swamp on Washington creek. V. Collected in the moss in the tamarack swamp. VI. Several found beneath the bark of fallen spruce trees in the coniferous forest.

6. *Zonitoides milium* (Mse.). Specimens of this form were collected among the leaves and in fallen birch logs in the deciduous forest, III; in the moss of the tamarack swamp, V, and beneath the bark of fallen spruce trees, VI.

7. *Vitrea binneyana* (Mse.). II. Taken among the fallen leaves in an alder thicket on a mud flat on Washington river, and in the moss in the coniferous forest bordering the river. Specimens were found under stones and among the fallen maple leaves in the deciduous forest, III; in the humus of the cedar swamp, IV; in the fallen spruce logs in the coniferous forest, VI, and in the moss of the tamarack swamp, V. A few specimens were also found in the moss among the bearberry bushes on the Minong Trap promontory, IX.

8. *Zonitoides exigua* (Stimp.). II. Found among the fallen leaves of an alder thicket on a very wet mud flat, and in the moss covering the ground in the coniferous forest bordering the river. Collected among the fallen leaves in the deciduous forest, III; in the moss of the arbor vitae swamp, IV, and in the moss of the tamarack swamp, V. Also found in the moss among the bearberry bushes on the Minong Trap promontory, IX.

9. *Pyramidula alternata* (Say). III. Among the damp fallen leaves, beneath the bark of fallen birch logs, and under stones in the deciduous forest.

10. *Pyramidula striatella* (Anth.). This species was collected on Washington river, II, among the fallen leaves of alders on a mud flat, and in the moss in the coniferous forest, bordering the river. It was also collected in

the deciduous forest, III, among the damp fallen leaves and under rocks; in the humus of the cedar swamp, IV; in the moss in the tamarack swamp, V, and in the moss among the heath plants on the Minong Trap promontory, IX.

11. *Pyramidula striatella alba* (Walker). II. In the moss forming the ground cover of the coniferous forest. III. Several specimens were also collected among the damp fallen leaves in the deciduous forest.

12. *Pyramidula asteriscus* (Mse.). III. Taken among the fallen leaves in a moist ravine in the deciduous forest.

13. *Acanthinula harpa* (Say). II. This species was found to occur in the moss ground cover of the coniferous forest bordering Washington river; in the humus of the arbor vitae swamp, IV, and in the moss about the roots of the heath plants on the Minong Trap promontory, IX.

14. *Punctum pygmaeum* (Drap.). III. Several specimens of this form were collected among the damp fallen leaves in the deciduous forest.

15. *Sphyradium edentulum* (Drap.). II. Beneath the bark of a fallen log in the coniferous forest along Washington river, and among the fallen leaves in the deciduous forest, III.

16. *Euconulus fulvus* (Drap.). This shell was found beneath the bark of a fallen birch tree in the coniferous forest, II; among the fallen leaves in the deciduous forest, III, and in the moss of the tamarack swamp, V. A few dead shells were also found in the sediment in the bottom of Grace creek.

17. *Euconulus chersinus polygyratus* (Pils.). Collected in the moss and decaying logs in the coniferous forest on the flood-plain of Washington river, II; among the fallen leaves in the deciduous forest, III, and beneath the bark of a decaying tamarack stump, V.

18. *Vertigo ovata?* Say. A defective specimen was found in the humus of the arbor vitae swamp, IV.

19. *Vertigo gouldii* Binn. Among the fallen leaves in the deciduous forest, III, and in the moss of the tamarack swamp, V.

20. *Vertigo sp.* In the moss about the foot of a tamarack, V.

21. *Carychium exile* H. C. Lea. This species was found among the fallen alder leaves on a very wet flat along Washington river, II, and among the fallen maple leaves in the deciduous forest, III.

22. *Limnaea stagnalis* L. *var.* This snail is very abundant about the shores of Washington Harbor, X. The specimens collected were attached to the larger rocks that are not readily moved by the action of the surf.

23. *Limnaea* n. sp.? (related to *L. sumassi* Bd., but probably undescribed). X. This form is also abundant in Washington Harbor, and with *Limnaea stagnalis* constitutes the characteristic molluscan life of this station. The specimens collected were found clinging to the rocks under the same conditions as *L. stagnalis*. It was also found to occur commonly in the rock pools on the Minong Trap promontory, IX.

24. *Physa sayii* Tapp. *var.* X. This form was found only in Washington Harbor, where it occurs on the rocks near shore.

25. *Physa sp.* (probably *sayii* Tapp.). VIII. A few specimens were found at Siskowit Bay, attached to stones in the back water pools on the beach.

26. *Physa sp.* Under this head are grouped a number of immature shells collected in Lake Desor, VII, in the fine silt near shore and attached to large rocks about the islands; among the leaves of submerged aquatic

plants in Washington river, II, and attached to the rocks about the shore of Washington Harbor, X.

27. *Aplexa hypnorum* (L.). II. Found only among the fallen alder leaves on a wet flat on Washington river.

28. *Planorbis bicarinatus striatus* Baker. VII. This species was found in the silt near shore and on the rocks off the islands of Lake Desor.

29. *Planorbis exacuous* Say. II. A number of specimens were taken among the leaves of submerged aquatic plants in Washington river. It was also found on the rocks in shallow water about the islands of Lake Desor, VII, and in Washington Harbor, X.

30. *Planorbis parvus* Say. III. Collected among the leaves in the bed of a dry creek in the deciduous forest. Also found in the rock pools on the Minong Trap promontory, IX, and clinging to the rocks in shallow water about the islands of Lake Desor, VII.

31. *Planorbis hirsutus* Gld. This species was only found in Lake Desor, VII, where it occurs on the rocks in shallow water about the islands.

32. *Valvata sincera lewisii* Curr. VIII. A few specimens of this species were found on the rocks in a back water pool at Siskowit Bay.

33. *Anodonta marginata* Say. VII. Several specimens were collected in shallow water at the west end of Lake Desor, among a scattered vegetation of equisetum and water lilies. This is the only place where mussels were found on the south end of the island, with the exception of a broken shell in Washington Harbor, X, although a careful search was made for them about the shore of the harbor and in Washington river.

34. *Pisidium abditum* Hald. *var.* II. Several specimens were collected among the wet fallen leaves in the alder thicket, on the bank of Washington river.

35. *Pisidium variabile* Pme. II. Among the leaves of a submerged aquatic plant in Washington river.

36. *Pisidium sp.* Pisidia which could not be identified were collected on water plants in Washington river, II; in the silt in the bottom of Washington creek running through the arbor vitae swamp, IV, and in the debris in the bottom of Grace creek, near its mouth.

The following general observations on the collection will call attention to the specimens of special interest and to their faunal affinities. So far as Isle Royale is concerned, the fauna is purely boreal; the land species, as far as they go, are the same (with one exception) as those of the Porcupine Mountains, Ontonagon County. The only species not found in Ontonagon County is *Pyramidula striatella* Anth. The occurrence of the typical form of *striatella* on Isle Royale while the Ontonagon County form is uniformly var. *catskillensis* Pils., is very curious. *Catskillensis* is the characteristic form of Northern Michigan. It has been traced from Beulah, Benzie County, Mich. north through the Grand Traverse region, Mackinac Island and the St. Mary's river, to Marquette, Baraga and Ontonagon Counties. At Charlevoix both forms occur, while specimens from Crooked Lake, Emmet County, are rather intermediate. On the main land of the Upper Peninsula thus far only the variety has been found.

Among the aquatic species, however, Isle Royale furnishes some interesting forms. The form of *Limnaea stagnalis* is a peculiar and well marked

one, quite different from any of the described forms. The occurrence of the *Limnaea* related to *L. sumassi* Bd. on Isle Royale is a very interesting discovery, and, whether distinct or merely a variety of that form, is new to the Michigan fauna. Originally described from British Columbia *L. sumassi* is peculiarly a western species, and its occurrence so far east, if these shells are referred to it, is quite unexpected. *Planorbis bicarinatus striatus* Baker has not before been listed in the Michigan fauna, as it was described since the last (1894) general catalogue of the Mollusca of the State was published. It is, however, a form of general distribution through the northern part of the state and occurs occasionally in the southern counties. (Raisin river, Monroe Co. and Orchard Lake, Oakland Co.). The *Pisidia* are represented by several interesting forms, some of which are probably undescribed species, but the amount of material is at present too meager to justify a decisive opinion. It is a matter of regret that this interesting group was not more largely represented in the collection. The collection from the Porcupine Mountains is necessarily largely the same as that made in 1903, and affords no occasion to vary the opinion as to the general character of the fauna already expressed in the report on these collections.*

The specimens of *Cochlicopa lubrica* from the hardwood forest, II. 2, are the elongated slender form described by Doherty as *morseana*. It has not been listed before from this State. *Acanthinula harpa* and *Zonitoides asteriscus* are boreal species, the former hitherto found only at Beulah, Benzie Co., Charlevoix and Petoskey, and the latter at Charlevoix. Their occurrence on Isle Royale and in Ontonagon County are the first records for the Upper Peninsula. *Pallifera hemphilli* W. G. Binn. is a new species for Michigan and a very interesting one. It was originally described from Mount Mitchell, N. C. and Lulu, Hall Co., Ga. Dr. Pilsbry says, "It looks as though *hemphilli* might be a Canadian form which extends down the mountains. I have seen it also from the mountains in Pennsylvania."

*Sixth Report Mich. Acad. Science, 1904, p. 192.

SPIDERS AND INSECTS FROM THE PORCUPINE MOUNTAINS AND ISLE ROYALE, MICHIGAN.

A. G. RUTHVEN.

With the exception of the Odonata and Orthoptera, no attempt was made to make extensive collections of the different groups of invertebrates, and the lists comprise only the more characteristic forms in the different habitats studied. The collections were, for the most part, made by the author with the assistance of the other members of the party, except in the case of the ants which were collected largely by Mr. Otto McCreary. We are indebted to the following persons for the determination of the collections:

Spiders.—Mr. Nathan Banks, U. S. Department of Agriculture.

Dragonflies.—Mr. E. B. Williamson, Bluffton, Ind.

Butterflies and Moths.—Prof. Arthur J. Snyder, Springfield, Idaho.

Ants.—Dr. W. M. Wheeler, American Museum of Natural History.

1. SPIDERS FROM THE PORCUPINE MOUNTAINS.

1. *Gnaphosa conspersa* Thor. III. 1. Taken under a pine log among the dwarf huckle-and blueberry bushes in the aspen zone, August. 6.

2. *Linyphia phrygiana* Koch. I. Taken on the leeward side of projecting outcrops of rock on the beach of Lake Superior, July 21. Also occurs in Europe (Banks).

3. *Epeira trifolium* Hentz. I. This spider occurs numerously along the beach of Lake Superior. It weaves its web behind projecting outcrops of rock, and when surprised runs swiftly into the rock crevices. The webs are often filled with small white moths, July 30.

4. *Epeira patagiata* Clerck. I. This species was found under the same conditions as *Epeira trifolium*. Also occurs in Europe (Banks).

5. *Lycosa gracilis* Bks. III. 1. In a shallow hole in dead grass under a fallen pine log in the aspen zone, August 6.

6. *Pardosa lapidicina* Th. I. This species was taken on the beach of Lake Superior, July 30. It was observed quite frequently running about over the rocks, and dodging into the crevices when pursued.

7. *Pardosa. sp.* (probably *lapidicina*). I. Several immature specimens were taken on the rocks of the Lake Superior beach, July 21.

8. *Dolomedes tenebrosus* Hentz. II. 1. A specimen of this spider with its egg mass was taken on a cedar stump in the arbor vitae swamp, August 25.

2. SPIDERS FROM ISLE ROYALE.

1. *Amaurobius sp.* V. One specimen was found in the Sphagnum moss in a tamarack swamp, August 22.

2. *Amaurobius bennetti* Blackw. II. One specimen was taken in the moss ground cover of the balsam and spruce forest on the flood-plain of Washington river, August 26.

3. *Lycosa pratensis* Em. IX. Several specimens were found in the moss about the roots of the dwarf blueberry bushes on the Minong Trap promontory, September 2.

4. *Xysticus sp.* IX. One specimen was taken in the same habitat as the last, September 2.

Mr. Banks remarks in a letter, concerning the collection, that these species are all fairly common throughout the northeastern United States.

3. DRAGONFLIES FROM THE PORCUPINE MOUNTAINS.

1. *Calopteryx aequabilis* Say. IV. 2. A male was taken among the alder bushes along Carp river, August 5, and a female flying up the river, IV. 1, on August 12.

2. *Lestes unguiculatus* Hagen. II. 3. A male was taken in the clearing on August 12. III. 2. Two females were taken on the "bald" crest of the first range, resting on goldenrods, July 18. IV. 2. One male was taken on a cassandra bush in the valley of Carp river, August 5.

3. *Nehalennia irene* Hagen. V. 2. A female was collected on a grass stem on the delta of Carp river, August 12.

4. *Enallagma hageni* Walsh. V. 2. Twenty-one males and one female were taken on the delta of Carp river, on August 12, and four males on July 21. This is the only station at which this form was observed. It occurs here, however, abundantly, and is the characteristic species of this marsh.

5. *Enallagma carunculatum* Morse. V. 2. A single specimen of this form, a male, was taken on the delta of Carp river, August 12.

6. *Enallagma sp.* V. 2. A male was taken on the delta of Carp river on August 12.

7. *Ischnura verticalis* Say. V. 2. A female was taken on the delta of Carp river, July 21, resting on a grass stem, and a male and female in the same locality on August 12.

8. *Hagenius brevistylus* Selys. V. 1. Only one specimen of this form was collected, a female taken on Carp Lake, on an alder branch overhanging the water, August 10.

9. *Gomphus spicatus* Hagen. A male was taken in the clearing, II. 3, on July 16, a female, flying about among the cassandra bushes on the flood-plain of Carp river, IV. 2, August 5, and five males on the delta of Carp river, V. 2, July 21. The habitat of this form seems to be the marsh and river. The specimen taken in the clearing was the only specimen observed away from water.

10. *Aeschna clepsydra* Say. I. Several individuals resembling this form were observed, flying back and forth along the beach of Lake Superior on July 30. II. 3, 4. Two males and two females were taken about dusk on July 16, flying about the clearing and in and out among the surrounding aspens. V. 2. A male and female were captured in coitu among the grasses and sedges on the delta of Carp river, on August 8. IV. 1. Individuals resembling this form were often seen in the evening, flying up and down Carp river, and along Little Carp river, VII. 3, and over the lake, VII. 1, on August 3. This species seemed to occur generally along the streams, except in the evening, when it was also observed flying back and forth in the woodland clearings. The individuals seen flying over Little Carp Lake often made sudden swerves close to the surface, and nearly every time, as they flew upward again, they were followed by the snout of a hungry dace, but in no instance observed was the fish successful.

11. *Sympetrum obtrusum* Hagen. II. 3. One female was taken on July 16; many others were seen in the clearing at various times. II. 4. Five males and one female were taken in the aspen zone that surrounds the clearing, July 15 and 16. II. 5. Two males and two females were taken on the heath undergrowth in the aspen zone bordering the north side of the bald crest of the ridge, July 15. III. 1, 2. Several individuals of the genus, thought to belong to this species, were seen at different times, flying about over the heath plants, and in the aspen zone on the mountain top. III. 3. One specimen was taken among the pines on July 19. III. 4. Two males and one female were taken on July 15 in the aspen zone that borders, on the east, the bald crest of the first range. IV. 2. Three males were taken among the cassandra bushes along Carp river on July 5. VII. 2. One taken and several seen on the beaver meadow on Little Carp river, August 3. This form seemed to occur most numerously in the cassandra zones and beaver meadows along the streams, although it was also observed to occur quite commonly in hardwood clearings and on the bald crests. It is not strictly confined to the clearings, however, but seems to occur in equal abundance in the aspen zones.

12. *Sympertum costiferum* Hagen. I. One male was taken on July 30, flying about over the beach of Lake Superior. This was the only specimen taken. Three others which resembled this form were seen resting on the beach, but they eluded capture. None were observed at any other station.

13. *Plathemis lydia* Drury. IV. 1, V. 2, VII. 2. No specimens of this form were taken, but a dragonfly was observed several times on the mudflats of Carp river, on the marsh at the east end of Carp Lake, and on the beaver meadow, that can be referred to this species with little doubt.

4. BUTTERFLIES AND MOTHS FROM THE PORCUPINE MOUNTAINS AND ISLE ROYALE.

a. Porcupine Mountains.

1. *Argynnis cybele* Fab. II. 3. One specimen of this form was taken on the flower of a cow parsnip in the clearing, July 20, and one on a goldenrod on the mountain top, III. 2, on August 10. Argynnid forms resembling this species were often seen about the clearing, "balds" and river valley, but how many of these were to be referred to the species, and to the following variety, was not determined.

The observations and collections indicate that both the variety and typical forms prefer an open sunny habitat.

2. *Argynnis cybele* Fab. *var.* (near *leto*). For a discussion of this variety see Prof. Snyder's comments on the collection at the close of the Isle Royale list. II. 3. One specimen was taken, flying about the clearing, July 21, and one on Carp river, IV. 2, flying about among the cassandra bushes on August 12.

3. *Argynnis atlantis* Edwards. Specimens of this species were collected on the beach of Lake Superior, I, August 11, in the clearing, II. 3, July 16, and in the valley of Carp river, IV. 2, August 12.

4. *Phyciodes tharos* Drury. I. Two were taken, flying over the beach of Lake Superior, July 30 and August 11, and two on a harebell on July 17. II. 3. Two specimens were also found on a cow parsnip flower in the clearing, July 16. This species like the Argynnids, seems to prefer open sunny habitats.

5. *Grapta gracilis* Grote and Robinson. I. Five specimens were taken on the rocks and flying about over the beach of Lake Superior on August 11. II. 3. One was collected in the clearing, August 7, and one on the face of the cliff, III. 6, August 11. This form is the characteristic butterfly of

the beach. The one captured in the clearing was the only one observed there. They were numerous on the face of the cliff, but, owing to the difficulty in scaling the precipice, only one could be secured. Both on the cliff face and beach, they made but short flights when disturbed, and if not pursued soon settled on the rocks again. After alighting they settled close to the rocks with their wings outspread, now and then raising them above their back, but quickly lowering them again.

6. *Grapta progne* Cramer. I. One specimen of this butterfly was taken, flying over the beach of Lake Superior, August 11.

7. *Vanessa j-album* Boisduval and Leconte. This form was taken on the beach of Lake Superior, I, on August 11. Two individuals were collected in the clearing, II. 3, on August 5, and August 7. III. 2. One specimen was also found on the talus slope, July 21.

8. *Vanessa antiopa* Linn. I. One taken on the beach of Lake Superior, August 11. This butterfly was not often seen. It was twice recognized in the clearing, II. 3, once on the shore of Carp Lake, V. 1, and once in the beaver meadow on Little Carp river, VII. 2.

9. *Basilarchia arthemis* Drury. This form was found to occur on the beach of Lake Superior, I, in the clearing and surrounding aspen zone, II. 3, 4, in the cassandra zone on Carp river, IV. 2, and in the beaver meadow. It is a very common form in this region, being apparently of general distribution in clearings

10. *Thecla edwardsii* Saunders. III. 2. One specimen was collected on a goldenrod on the mountain top, August 10.

11. *Colias philodice* Godart. I. Two specimens were taken on harebells on the beach of Lake Superior, August 30, and three flying about, August 11. II. 3. One was found on a cow parsnip in the clearing, August 7. "Yellow" butterflies were not often observed

12. *Catocala unijuga* Walker. II. 3. One specimen was found in a crevice between the logs of the camp shack in the clearing, August 5.

13. *Hypoprepia miniata* Kirby. III. 6. On a huckleberry bush on the "bald" mountain top, August 11.

14. *Actias luna* Linn. II. 2. A single specimen was taken on a hemlock, July 15.

b. Isle Royale.

Basilarchia arthemis and *Colias philodice* were both common in the clearings. One specimen of *Vanessa antiopa* was seen in a clearing, September 3.

c. Notes on the Collection of Butterflies, by Prof. A. J. Snyder.

Of all the lot the most interesting are the two varieties of the female of *Argynnis cybele*, which so closely resemble the female of *Argynnis leto* as to startle one. The same form was found in the Lake Superior region by Mr. Bates of Chicago. I believe two specimens of this form are now in the collection of Mr. John Healey of Chicago. The two specimens listed above well illustrate geographic variation.

Dr. Holland speaks of *Carpenterii*, the variety of *cybele* found in New Mexico and Colorado, and claims a similar form is found in Labrador and Canada; also on the mountains of Carolina. The largest forms of *cybele* I have seen are from Tennessee. *Argynnis leto* is a western species common in Utah and some parts of Colorado. The dark female, at its best, is a handsome specimen, and that a female of *cybele* should be found in the Superior country is enough to make one question the ancestory of *leto*. Of one thing we are

certain, altitude and latitude both tend to make smaller and darker colored specimens of a species.

57 ANTS FROM THE PORCUPINE MOUNTAINS.

1. *Formica impexa* Wheeler.* III. 6. A colony of this form was found beneath a loose stone among the huckleberry bushes on the mountain top, August 12, 1904 (not 1902 as given by Wheeler).

"*Worker*. Length 3.3—6 mm.

"With the habitus of *Formica rufa*. Mandibles 8 toothed. Clypeus broadly rounded in front, not produced in the middle, carinate its entire length. Head excluding the mandibles, distinctly longer than broad even in the largest workers. Cheeks rather long, straight, subparallel. Posterior border of head straight, posterior corners rounded. Joints 1-4 of antennal funiculus decidedly longer and more slender than the remaining joints. Thorax of the *rufa* type, but with the epinotum very low and rounded. Petiole rather thick anteroposteriorly, its anterior surface convex in profile, its posterior flattened, its edge, especially in smaller workers, very blunt. Seen from behind the node is produced upwards in the middle and is of rather variable outline, being notched in the middle in some specimens, but oftener more or less rounded.

"Mandibles lustrous, finely and sharply striated. Surface of clypeus uneven. Frontal area shining. Remainder of body opaque, distinctly but finely shagreened.

"Whole body and appendages covered with very minute white pubescence, which is rather sparse on the head and thorax, but dense and concealing the ground surface on the gaster. Body, antennal scapes, and legs covered with robust, obtuse, erect or suberect, whitish or yellowish hairs. On the gaster they are uniformly distributed and very conspicuous in certain lights. They are also very numerous and prominent on the upper surface of the thorax, clypeus, front, vertex, posterior corners and lower surface of the head. They are absent or very sparse on the cheeks, pleurae and coxae. On the legs they are prominent both on the flexor and extensor surfaces.

"Head and thorax red. Gaster black. All specimens, even the largest are more or less infuscated as follows: Mandibles, anterior border of clypeus and apical half of funiculi dark reddish brown. Ocellar triangle, upper surface of pro- and mesonotum, much of the upper portion of the petiole, legs and coxae, except their articulations, more or less blackened. In the largest workers the fore coxae are largely red. Anal region and articulations of legs yellowish. In the smallest workers the infuscation is more extensive, involving the whole of the posterior portion of the head and the epinotum.

"Described from twelve workers taken August 12, 1904 by Mr. O. McCreary from a colony nesting under a stone in the Porcupine Mountains, Ontonagon county, Michigan. Types in the American Museum of Natural History, cotypes No. 32,925 in the University Museum, University of Michigan, Ann Arbor, Mich.

"*F. impexa* is allied to *F. oreas* Wheeler and *F. microgyna* Wheeler, with which it agrees in having erect hairs on the antennal scapes. It differs from *F. oreas* in the much stiffer and less abundant erect and obtuse hairs on the head and thorax, the prominent hairs on the gaster, the longer head, more opaque surface of the head and thorax, etc. In most of these characters

*Wheeler, W. M. New Species of Formica. Bull. Amer. Mus. Nat. His., XXI, p. 273, 1905.

it also differs from the typical *microgyna*. The erect hairs on the gaster of *impexa* are much more robust and obtuse than in the latter species. The new species also resembles *F. difficilis* Emery and notably its var. *consocians* Wheeler, except in pilosity and the absence of any yellow color on the basal gastric segment.

"It is very probable that the female of *F. impexa* is aberrant, either in being very diminutive like the females of *F. difficilis* and *F. microgyna* or in having an unusual color like the female of *F. oreas*. Until this sex of *impexa* is discovered there may be some doubt as to whether the form should be regarded as a species distinct from *rufa*. That it differs very markedly in pilosity from all the hitherto described subspecies and varieties of *rufa*, there can be no doubt." W. M. Wheeler.

2. *Formica fusca* L. var. *subsericea* Say. III. 6. On the rocks at the foot of the talus slope and at the foot of the cliff, August 12. Also found in an ant hill in the clearing, II. 3, and under the loose stones on the mountain top, III, August 6.

3. *Formica fusca* L. var. *argentata* Wheeler. III. 1, 2. A number of colonies were found under the loose rocks on the mountain top, especially among the heath plants.

4. *Formica fusca* L. var. *neorufibarbis* Emery. II. 4. A colony of this species was found in a decaying aspen log, August 8.

5. *Formica lasioides* Emery. var. *picea* Emery. III. 2. Collected under the loose stones on the mountain top, August 11.

6. *Brachymyrmex heerii* Mayr. subsp. *depilis* Emery. III. 6. Under stones on the mountain top, August 12. III. 2. Taken among the heath plants on the mountain top, July 18.

7. *Tapinoma sessile* Say. (small var.). III. 1. Under the stones in the aspen zone near the top of the first range, August 11, and on III. 6, under the loose stones on the side of the mountain near the top on August 12.

8. *Camponotus herculeanus* L. var. *whymperi* Forel. III. 2. A colony was found in a dry decaying pine log on the bare mountain top, August 6. and in a decaying pine log on the mountain top, III. 6, August 12.

9. *Lasius brevicornis* Emery. III. 2. Beneath the loose rocks on the mountain top, August 11.

10. *Spenamma* (*Aphaenogaster*) *fulvum* Roger. var. *rude* Emery. III. 6. Collected beneath the stones near the top of the mountain, August 12, and under stones and fallen pine logs in the aspen zone near the top of the ridge, August 6.

6. ANTS FROM ISLE ROYALE.

1. *Formica sanguinea* Latr. subsp. *aserva* Forel. I. One colony found in the clearing, August 18.

2. *Formica fusca* L. var. *subsericea* Say. I. Several colonies were found in the clearing, August 18.

3. *Formica fusca* L. var. *neorufibarbis* Emery. I. In the humus beneath a decayed stump in the clearing, August 18. III. In a decayed log on the top of the ridge, August 20.

4. *Camponotus herculeanus* L. var. *whymperi* Forel. I. Found on sides of a log shack, August 18, and feeding on a fish head in the clearing, September 1.

5. *Leptothorax canadensis* Prov. var. I. One colony found in the clearing, August 18.

Dr. Wheeler makes the following comments on the collection: "The

collection is a very interesting one. All the forms are subboreal and characteristic of the hills or mountains of the northern states or British Columbia. The new *Formica* [*impexa*] is especially interesting. Unfortunately only workers are represented. The female is probably an aberrant form like the female of *F. oreas* or *F. ciliata*. All the other species are well known, with the exception of *F. aserva* and *Camponotus whymperi*. The latter occurs in the mountains of Colorado and British Columbia."

THE COLD-BLOODED VERTEBRATES OF THE PORCUPINE MOUNTAINS AND ISLE ROYALE, MICHIGAN.

A. G. RUTHVEN.

The list of fish in the following report is entirely the result of the work of this expedition, and we are indebted to Dr. S. E. Meek of the Field Columbian Museum, Chicago, for the identification of the specimens.

The list of amphibians and reptiles is intended to include the data at present available to the author on the occurrence of these animals in the Northern Peninsula. It is of necessity far from complete, as very little collecting has been done in this region, and the records that have been made are scattered. For the latter reason it was thought best to bring together all available information. The sources of the records are the collections made for Mr. Bryant Walker about Limestone Mountain, Baraga County, and in the Porcupine Mountains, Ontonagon County, in the summer of 1903*; the collections and field notes of the Museum Expedition in the Porcupine Mountains and on Isle Royale, during the summer of 1904; records and collections made about Marquette by Dr. E. R. Downing of the Northern State Normal School, and specimens in the University Museum collected by Dr. A. E. Foote on Isle Royale. A few notes have also been added from specimens collected during the summer of 1905, by Dr. C. A. Davis of the Michigan Geological Survey.

The amphibians, with the exception of the Marquette specimens, have been identified by Dr. Stejneger of the United States National Museum; the Marquette specimens, and the reptiles were identified by the writer, unless otherwise stated.

1. FISH FROM THE PORCUPINE MOUNTAINS.

1. *Catostomus commersonii* (Lacépede). Fine Scaled or Common Sucker. IV. 1. Ten specimens were taken in the deeper holes in Carp river near Carp Lake, July 16, on a bottom of fine mud. V. 3. Twelve specimens were collected near the center of Carp Lake on July 16. VII. 1. One was taken and several others seen off the edge of the delta of Little Carp river, August 3. VII. 3. Two specimens were collected in a pool about five feet deep behind a beaver dam on Little Carp river, August 3. This is the characteristic and common fish in the deeper waters of this region.

2. *Semotilus atromaculatus* (Mitchell). Horned Dace. IV. 1. Thirteen specimens were taken in Carp river on July 16 and 18. This fish seemed to occur only in small numbers in the deeper water near the lake, but farther up stream, where the current is more rapid, it was very abundant, although the bottom was still composed of mud and debris. No specimens were taken in Carp Lake, but it is abundant in Little Carp Lake, VII. 1, where

*Ruthven, A. G.—Notes on the Mollusks, Reptiles and Amphibians of Ontonagon County, Michigan. Sixth Annual Report Michigan Academy of Science, pp. 188–192.

thirty-four specimens were taken, August 3. In the latter, locality they were observed repeatedly about dusk to jump partly out of the water in pursuit of dragonflies.

3. *Nototropis cayuga* Meek. IV. 1. Four specimens were taken off a mud flat in Carp river on July 16, among a vegetation of water lilies.

4. *Nototropis hudsonius* (DeWitt Clinton). Spawn Eater or Shiner. IV. 1. Four specimens were taken off a mud flat in Carp river, and many others in Carp Lake, V. 3, in about six feet of water, off a gravelly shore, July 16.

5. *Nototropis cornutus* (Mitchell). Shiner; Red Fin. VII. 3. One specimen of this form was taken in Little Carp river. This fish was observed to occur much more numerously up stream, where the current was swift and the bottom composed of gravel, than in the deeper water near the lake.

6. *Couesius plumbeus* (Agassiz). VII. 3. Six specimens of this fish were collected in Little Carp river at about the middle of the beaver meadow, where the stream is shallow, current quite rapid, and the bottom composed of small stones.

7. *Salvelinus fontinalis* (Mitchell). Brook Trout. Owing to the preference of this species for clear cold streams with a swift current and gravel bottom, it is not surprising that it does not occur in Carp Lake or Carp river within the mountains. It is reported by Mr. Allie, of the Carp Lake Mine, to be abundant in Little Carp Lake during the spring and early summer, but we were unable to obtain any in August.

8. *Thymallus ontariensis* (Cuvier and Valenciennes). Grayling. This fish was not taken, but specimens were seen by the writer in the summer of 1903, which had been taken in Little Carp river, near Lake Superior.

9. *Eucalia inconstans pygmaea* (Agassiz). VII. 3. One specimen was taken in Little Carp river on August 3, where the current was quite rapid and the bottom composed of fine silt. Several others were seen in a small creek cut in the loam of the beaver meadow.

10. *Percopsis guttatus*, Agassiz. Trout Perch. IV. 1. Three specimens were collected in shallow water off a mud flat in Carp river, and in the deeper waters of Carp Lake, V. 3. This genus and species were originally described by Agassiz[1] from specimens taken in the Lake Superior region. Its habitat is given by Forbes[2], as apparently deeper waters, not often found in streams, and by Jordan and Evermann,[3] as "cold or clear lakes and rivers." It, however, occurs in the Porcupine Mountains, in quite shallow water. This may be due to the fact that it is a northern form, and that in this region the conditions to which it is adapted are more widespread than toward the south.

11. *Perca flavescens* (Mitchell). Yellow Perch. IV. 1. Four specimens were collected in the deeper parts of the river near Carp Lake, and twenty-five in the lake, V. 3. These specimens were all obtained in the deeper parts of the lake and river, where there was considerable vegetation and muddy bottom.

2. FISH FROM ISLE ROYALE.

1. *Catostomus commersonii* (Lacepede). Common Sucker. X. Often seen in large schools near the shore of Washington Harbor. The conditions were: bottom rocky, and little or no vegetation.

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[1]Agassiz, Louis. Fishes of Lake Superior compared with those of the other Great Canadian Lakes. p. 284. Lake Superior its Physical Character, Vegetation, and Animals. Boston, 1850.

[2]Forbes, S. A. A Catalogue of the Native Fishes of Illinois. Rep. Ill. State Fish Com., 1886, p. 96.

[3]*Jordan and Evermann.* The Fishes of North and Middle America. Bull. U. S. Nat. Mus., No 47, *Pt. I, p. 784.*

2. *Couesius plumbeus* (Agassiz). The type of this species was from Lake Superior.* It occurs abundantly in Washington Harbor, X, where eight specimens were taken, August 31, just off shore, on hooks baited with worms.

3. *Argyrosomus artedi* (LeSueur). Lake Herring. X. The Herring was observed in large schools in Washington Harbor at different times; one was taken in a gill net out in the harbor, and one near shore in about fifteen feet of water, August 31.

4. *Cristivomer namaycush* (Walbaum). Lake Trout. X. This fish was taken at various times by trolling off rocky reefs in Washington Harbor and along the north shore of the island. The weight of those taken varied from 5 to 12 pounds.

5. *Salvelinus fontinalis* (Mitchell). Brook Trout. This trout occurs abundantly in Washington river, II, and individuals were often observed in the Herring schools in Washington Harbor, just off shore, X.

6. *Lucius masquinongy* (Mitchell). Muskallunge. X. But one specimen of this fish was observed, which was speared with a cant hook near the shore of Washington Harbor on August 2. Weight 13 pounds.

7. *Perca flavescens* (Mitchell). Yellow Perch. X. Occasionally taken in Washington Harbor on hooks bated with worms.

8. *Cottus ictalops* (Rafinesque). Millers Thumb. X. Occurs among the large rocks along the shore of Washington Harbor.

3. THE AMPHIBIANS OF THE NORTHERN PENINSULA.

1. *Plethodon glutinosus* Green. Slimy Salamander. I have examined a specimen of this salamander collected by Dr. E. R. Downing at Marquette. He reports it as occurring commonly in that locality.

2. *Plethodon cinereus erythronotus* Green. Red-backed Salamander. Specimens of this form were taken in decayed logs, especially in damp places, at Limestone Mountain, Baraga County, in August, 1903, and in the Porcupine Mountains in August and September, 1903. It is also reported by Dr. Downing from Marquette.

3. *Diemyctylus viridescens* Raf. Green Triton or Newt. I have examined a specimen of this form taken by Dr. Downing from a small tributary to Dead river, near Marquette.

4. *Bufo americanus* (Lec.). Common Toad. Found commonly in the woods both at Limestone Mountain and in the Porcupine Mountains in the summer of 1903, and in the Porcupine Mountains and on Isle Royale, in the same habitat, in the summer of 1904. It is reported by Dr. Downing as common at Marquette. There are also four specimens in the University Museum collected by Dr. A. E. Foote on Isle Royale, where the notes of the Museum Expedition indicate that it is very common.

5. *Hyla pickeringii* Storer. Pickering's Tree Frog. A specimen of this little frog was taken on a fern in a damp ravine at Limestone Mountain in the summer of 1903, and another on a rush in the beaver meadow on Little Carp river, VII. 2, in the Porcupine Mountains on August 3, 1904. A specimen was also taken by Dr. C. A. Davis near Winona, Houghton County, on September 1, 1905.

6. *Hyla versicolor* Lec. Chameleon Tree Frog. Dr. Downing writes me that he has taken this species at Marquette. There is also a record in the University Museum (Museum Catalogue, Vol. 2, p. 196) of a specimen

*Agassiz, *loc. cit.*, p. 366.

(No. 7457) taken on Isle Royale by Dr. Foote, which I have been unable to verify.

7. *Rana pipiens brachycephala* Cope. Leopard Frog. The distinction between the typical form of this species and the so-called variety *brachycephala* does not seem to be a good one. If it is, the specimens recorded from the Northern Peninsula, according to Dr. Stejneger, probably belong to the variety. The specimens collected on the shores of Carp Lake in the summer of 1903, and recorded as *R. pipiens*,* belong to this form. Specimens were also taken here, V. 1, 2, during the summer of 1904, and Dr. C. A. Davis captured four specimens near Winona, Houghton County, September 1, 1905. The "Leopard Frog" is abundant about Marquette, according to Dr. Downing. Owing to the resemblance between this species and *R. palustris* Lec. several specimens from the Porcupine Mountains were listed provisionally as *palustris* in the 1903 list. These have all been identified by Dr. Stejneger as *R. pipiens brachycephala.*

8. *Rana septentrionalis* Baird. Mink Frog. This species is more aquatic than the other members of the genus found in this region, and specimens are thus more difficult to capture. A number of specimens were taken along the shores of Carp Lake, V. 1, and river, IV. 1, in the summer of 1904. It is also reported by Dr. Downing at Marquette, and there is in the University Museum a specimen taken by Dr. A. E. Foote on Isle Royale, that is labeled *R. clamitans*, but, owing to its condition, it is impossible to tell whether it is to be referred to this species or *clamitans.* As it is labeled *clamitans*, however, it should probably be listed with that species.

9. *Rana clamitans* Daud. Green Frog. This is probably the most common frog in the Northern Peninsula, at least in the western part. Several specimens were taken in Otter river near Limestone Mountain in August, 1903, and it was found to be abundant in Carp, IV. 1, and Little Carp river, VII. 3, and Lakes, V. 1, and VII. 1, in 1903 and 1904. At least one of the two specimens listed as *catesbiana* in the 1903 list belongs to this species, and perhaps also the other. They are both characterized by an obscurity of the dorso-lateral folds. In the former specimen this obscurity is more pronounced than in the latter, but Dr. Stejneger states that the slight webbing of the toes in the latter indicates that it, also, belongs to this species.

10. *Rana catesbiana* Shaw. Bull Frog. See *R. clamitans.* Dr. Downing reports this species from Marquette, but it is doubtful whether his specimens are to be referred to this species or, as the Porcupine Mountain specimens, to *clamitans.*

11. *Rana sylvatica cantabrigensis* Baird. Cambridge Frog. This variety of the Wood Frog is one of the most common amphibians in the localities where collecting has been done in the Upper Peninsula. It was found to be abundant in damp woods, especially about springs, both at Limestone Mountain and in the Porcupines, during the summers of 1903 and 1904. A single specimen was also taken on the shore of Lake Desor, Isle Royale; this was, however, the only one seen on the island. To this variety are to be referred the specimens that were listed in 1903 as *R. sylvatica.*

4. THE REPTILES OF NORTHERN MICHIGAN.

1. *Storeria occipitomaculata* (Storer). Storer's Snake. A single specimen of this snake was taken in the Porcupine Mountains in 1903, and a number of specimens collected about Marquette by Dr. Downing have been examined.

*Ruthven, *loc. cit.*, p. 191.

During the summer of 1904, eight specimens were taken on Isle Royale. These snakes, as has been stated by Smith,* appear to be somewhat nocturnal although not strictly so, and the specimens found on Isle Royale were taken, for the most part, under stones in the coniferous, VI, and deciduous forest, III. On September 3, after a heavy frost, four adult specimens, very sluggish on account of the cold, were found under a stone in the woods. These were brought to Ann Arbor alive. One of these snakes, University Museum Catalogue No. 33408, during the night of September 7 gave birth to a single young, and the next morning was found dead; the young one died the following night. The mother was examined at once, and six entire and two mutilated embryos were removed. As the mutilated specimens were nearest the opening of the oviduct, it is possible that they may have been killed by an injury to the mother in rolling over the stone under which she was found, and prevented the birth of those that lay behind them. The young snake was 45 mm. long, of a rich dark brown above, and pink below. As in the adult specimens, the pink was confined to the center of the gastrosteges, not extending to the edges. The upper occipital spot was bright yellow and well defined; the laterals smaller and less distinct, although plainly present.

Another adult, University Museum Catalogue No. 33409, died on September 10. This is also a female and possesses four nearly mature embryos in the right oviduct. The left oviduct is flattened out against the dorsal body wall and contains but one very small embryo which lies in the lower part of the oviduct; notwithstanding its small size, however, it is evidently nearly mature, as the yolk has entirely disappeared.

During the night of September 19, a third specimen, University Museum Catalogue No. 33410, gave birth to nine young, one of which was dead. The fourth specimen, University Museum Catalogue No. 33411, during the night of September 26 gave birth to seven young, one of which was dead. These records are interesting on account of the questions which they raise, as to the size of the young at the time of hibernation. On the Isle, during the first part of September, the nights were cold, and heavy frosts occurred frequently, so that the specimens found in the morning were very sluggish, and the time of hibernation was probably near at hand.

Since the above was written, the University Museum has received two specimens from Dr. C. A. Davis, which were taken on Paint River, near Crystal Falls, Iron County, on August 22, 1905.

2. *Diadophis punctatus* (L.). Ring-necked Snake. Specimens of this snake have been taken by Dr. Downing at Marquette.

3. *Thamnophis sirtalis sirtalis* (L.). Common Garter Snake. Specimens of the Common Garter Snake have been taken at Marquette by Dr. Downing, and near Limestone Mountain (1903), in the Porcupines (1903 and 1904), and on Isle Royale (1904). They are more commonly found along the streams, although they are also often found in forest clearings. The University Museum has recently received a specimen from Dr. C. A. Davis, which was taken in the woods near Bessemer, Gogebic county, August 28, 1905. There are four specimens (No. 7454) listed in the University Museum Catalogue, Vol. 2, p. 196, as taken on Isle Royale by Dr. Foote. These specimens are probably the basis for Smith's Isle Royale locality.†

4. *Thamnophis sirtalis parietalis* (Say). Pacific Garter Snake. This

*Smith, W. H. Report on the Reptiles and Amphibians of Ohio, p. 698. Geological Survey of Ohio, Vol. IV., 1882.

†Smith, loc. cit., p. 680.

snake has been listed from the Lower Peninsula,* but I have never seen a specimen from southern Michigan that could be definitely referred to this variety. *Sirtalis* forms with a varying amount of red on the skin between the lateral spots are often found about Ann Arbor, but the amount of red is so small that it is generally more satisfactory to classify the specimens with the typical form. During the past summer, however, three specimens were taken on Isle Royale, II, III, that strikingly resemble specimens from Colorado and Washington and can only be referred to the variety. The dorsal row of spots, as in typical specimens of the variety, are fused into a band along either side of the dorsal stripe, which is united below with the row of spots above the lateral stripes. Between the scales the skin is Orange Red Tint No. 1 (using Milton Bradley colors). One of these is a female containing 28 embryos not yet mature, as a large yolk body is present.

5. *Thamnophis saurita* (L.). Riband Snake. There is a record in the University Museum Catalogue, Vol. 2, p. 196, of a specimen (No. 7452) of this snake taken on Isle Royale by Dr. Foote, which I have been unable to verify.

6. *Chrysemys marginata* Agassiz. Painted Tortoise. A number of specimens were taken on Carp river, IV. 1, in the Porcupine Mountains in 1904. It is also reported from Marquette by Dr. Downing.

*Clark, H. L. Notes on the Reptiles and Batrachians of Eaton County. Fourth Annual Report Michigan Academy of Science, pp. 192–194.

ANNOTATED LIST OF THE BIRDS OF THE PORCUPINE MOUNTAINS AND ISLE ROYALE, MICHIGAN.*

N. A. WOOD, MAX M. PEET, AND O. MCCREARY.

1. PORCUPINE MOUNTAINS.

The following observations upon the birds cover a period from July 13 to August 13, 1904. For the determination of certain specimens from both the Porcupine Mountains and Isle Royale, we are indebted to Mr. Robert Ridgway and Mr. H. C. Oberholser of the Smithsonian Institution, and to Dr. C. Hart Merriam, Chief of the Biological Survey of the U. S. Department of Agriculture.

1. *Podilymbus podiceps.* Pied-billed Grebe. Station VII. Sub. 1. One seen on Little Carp Lake, August 3. VII. 3. One was seen August 7, on Little Carp river.

2. *Gavia imber.* Loon. I. One seen on Lake Superior August 5, and two July 21. V. 3. One seen on Carp Lake August 10.

3. *Larus argentatus.* Herring Gull. I. Several adults observed at various times along the lake. Common at Ontonagon, Mich., July 12, 13, and August 13 and 14.

4. *Merganser americanus.* American Merganser. I. An adult female and nine or ten young were seen July 21 on Lake Superior.

5. *Lophodytes cucullatus.* Hooded Merganser. IV. 1. Adult female and young found on Carp river, July 19 and 20; also observed July 18.

6. *Botaurus lentiginosus.* American Bittern. I. One seen in the bushes along the lake shore, August 12. IV. 1. One seen along Carp river July 18, and one shot July 19.

7. *Ardea herodias.* Great Blue Heron. IV. 1. One seen July 16. V. 2. One adult male in breeding plumage seen at Carp lake, August 6. One was seen flying across Carp Lake, July 30.

8. *Porzana carolina.* Sora. V. 2. An adult male taken on the delta at the eastern end of Carp Lake, August 5.

9. *Gallinago delicata.* Wilson Snipe. IV. 1. An adult male taken along Carp river, July 19. One observed feeding July 17. IV. 2. One seen in a grassy marsh along Carp river, July 18.

10. *Actodromas minutilla.* Least Sandpiper. I. One seen along the Lake Superior shore, July 21. VII. 2. Adult male taken and several specimens seen at the beaver meadow on August 3.

11. *Totanus flavipes.* Yellow-legs. VII. 2. Immature and adult males taken at the beaver meadow August 3.

12. *Helodromas solitarius.* Solitary Sandpiper. I. One seen on the Lake Superior beach, July 27. IV. 1. Immature males, adult male and females, taken along Carp river, July 27 and 28. Common along Carp river, July

*A preliminary note was published by N. A. Wood, Auk, XXII, pp. 175–178, 1905.

18 and August 10. VII. 2. Several were seen along Little Carp river in the beaver meadow.

13. *Actitis macularia.* Spotted Sandpiper. I. One male taken on the Lake Superior beach August 13. IV. 1. Two seen along Carp river, August 3.

14. *Bonasa umbellus togata.* Canadian Ruffed Grouse. II. 2. Several bevies of quite small young were seen July 17. Both old and young were seen several times. II. 3. Large bevies of young were seen in a clearing near camp. An adult bird was killed in the camp clearing by a Sharp-shinned Hawk. II. 5. A female with a large bevy of young was seen July 18. A large flock of young, unable to fly, and several nearly full grown were seen August 1. III. 2. Several flocks of both young and adults were seen on the mountain top during July. IV. 3. Both young and old were seen several times in the forest.

15. *Circus hudsonius.* Marsh Hawk. II. 3. An adult female was seen fighting with a Sparrow Hawk, August 8. IV. 2. A male was observed hunting, August 3. V. I. One was seen along the shore of Carp Lake August 3. VII. 2. One was seen near the beaver meadows, August 3.

16. *Accipiter velox.* Sharp-shinned Hawk. II. 1. An adult male taken July 27 and a female July 26. II. 3. One seen July 13 in the camp clearing. Several were seen below camp toward the Carp river. III. 5. They were frequently seen circling over the cliff in the morning. IV. 2. An adult female taken, August 7, near Carp river.

17. *Buteo borealis.* Red-tailed Hawk. II. 2. Two were seen flying overhead July 20. II. 3. One seen circling over the clearing August 8. III. Seen flying overhead on July 20, and at other times.

18. *Buteo lineatus.* Red-shouldered Hawk. One seen July 13 in the hemlock forest near Union Bay. The bird was on a tall dead tree, which afforded a good view of it (Wood).

19. *Buteo platypterus.* Broad-winged Hawk. II. 2. Young male, female and adult female taken August 12. The only ones seen.

20. *Haliaetus leucocephalus.* Bald Eagle. III. 5. One seen circling over the cliff, July 31, and two were observed on wing July 29. V. One was seen circling over Carp Lake July 29. Two were observed at Union Bay on July 23.

21. *Falco columbarius.* Pigeon Hawk. Several were seen at Union Bay and two were taken July 23.

22. *Falco sparverius.* American Sparrow Hawk. II. 1. Female taken in cedar swamp July 23. II. 3. One young female was taken August 4. Several were seen August 8, both young and adults. An immature male was taken July 28. These Hawks came into the camp clearing searching for grasshoppers. III. 5. Frequently observed sitting on dead stubs near the edge of the cliff in the early morning. IV. 3. A nest with young was found in an old pine stub in the hardwoods, July 16. Observed several times flying along the river. VII. 1. Seen at Little Carp Lake, August 3 and 7.

23. *Pandion haliaetus carolinensis.* Osprey. V. 3. One seen over Carp Lake July 23, and on August 10. One was also observed at Iron river, northeast of the Porcupines, July 13.

24. *Asio magellanicus occidentalis.* Great Horned Owl. II. 1. Young of the year taken and two others seen July 26. One seen among the hemlocks and maples, July 30.

25. *Coccyzus erythropthalmus.* Black-billed Cuckoo. II. 2. Was heard many times in the hardwood forest. II. 3. One was seen July 17 near the

camp. Late in the evening, about 9 p. m. of July 20, one was heard. One was seen July 15 in the aspens. An adult female was taken July 21. IV. 2. The call was heard many times in the alders. IV. 3. One was seen in the woods at the foot of the talus.

26. *Ceryle alcyon.* Belted Kingfisher. II. 3. One alighted upon the house top. IV. 2. Two birds were seen many times along Carp river. V. 3. One seen near Carp Lake July 16 and an adult female was taken July 28. VII. 1 and 2. Several were observed at Little Carp Lake and at the beaver meadows, August 2 and 3.

27. *Dryobates villosus.* Hairy Woodpecker. II. 1. One adult male was taken July 21 in the cedar swamp. II. 2. A young male was taken July 22, and adult females July 24 and 29. II. 3. An adult female was taken August 10 in the clearing. III. A male and female were seen August 10 on a dead Norway pine. III. 5. Often found on the dead stubs on top of, or overhanging the cliff. VII. 1. One seen at Little Carp Lake, August 7. VII. 2. One seen at the beaver meadow, August 3.

28. *Dryobates pubescens medianus.* Downy Woodpecker. II. 3. Young males were taken near camp August 2 and August 7, and an adult male was taken July 28. III. 3. Male and female seen near camp, August 10 on Norway pines. III. 5. Only seen once, August 12, upon a decayed pine stump. IV. 2. One seen in the tag alders, July 27. IV. 3. One was seen in the maples at the foot of the cliff, July 28. VII. One was seen August 6, at Little Carp Lake.

29. *Picoides arcticus.* Arctic Three-toed Woodpecker. II. 1. One was seen on the road to camp, July 13, and an adult male was taken July 21.

30. *Sphyrapicus varius.* Yellow-bellied Sapsucker. II. 3. A young female was taken near camp July 28. VI. One seen near Little Carp Lake, August 3, and again on August 9. One was seen at Little Iron river, east of the Porcupines, July 13.

31. *Coephlœus pileatus abieticola.* Northern Pileated Woodpecker. II. 1. A young female was taken July 27. II. 2. An adult female was taken August 1 in the hardwoods. "A young male was taken July 28 This I called to the tree nearest to me by clapping my hands, the method suggested in Chapman's Handbook. Two were called on this occasion and came within easy gun shot. After being called, they alighted and kept up a calling and drumming noise." (Peet). "In the hardwood forest I saw a dead hard maple which showed to good advantage the work of this bird. The tree contained many holes, some from 10 to 20 inches long; others 6 to 8 inches wide and deep. These birds seem to have the habit of working a tree very thoroughly." (Wood). VI. Several were seen and heard August 7 and 8, in the vicinity of Little Carp Lake. One was seen about a mile south of Carp Lake, on a hemlock. One was seen near Union Bay, east of the Porcupines, in a forest of large hemlocks with scattered white pine and a few maples, July 13.

32. *Colaptes auratus luteus.* Northern Flicker. II. 1. Several were seen in a clearing near the Lake Superior shore, August 4. II. 2. A young male was taken July 19. II. 3. One was seen July 17 flying over camp. III. 2. Several were seen and a young male was taken July 26, on the mountain top. Common, especially the young. III. 1. Several seen at different times on the stumps on the face of the cliff. IV. 3. One seen July 15, in the hardwoods near camp.

33. *Chaetura pelagica.* Chimney Swift. I. Several seen, flying overhead, along the Lake Superior shore, July 27. II. 3. Several were seen

in the evening of August 9 about camp, and an adult female was taken. IV. From the mountain top these birds were seen many times on wing over the valley of Carp river, July 19 and 20. V. Observed flying over Carp Lake on several occasions. Seen at the mouth of Carp river, July 31.

34. *Trochilus colubris.* Ruby-throated Hummingbird. VII. A female came many times to feed from flowers within about 20 feet of our breakfast camp fire, at Little Carp Lake, August 7. Another was seen at Little Carp Lake, August 9.

35. *Tyrannus tyrannus.* Kingbird. II. 1. Seen near the Lake Superior shore August 13. VI. One was seen near Little Carp Lake, August 7. On August 8 four birds, two young and two adults, were seen at a small lake two miles southwest of Little Carp Lake.

36. *Sayornis phoebe.* Phoebe. III. 5. Was seen on the south side of the cliff north of Carp Lake, July 29.

37. *Nuttallornis borealis.* Olive-sided Flycatcher. II. 1. Adult male and female were taken July 27, and an adult male was seen, and a female taken August 4, in an arbor vitae clearing near the Lake shore. IV. 4. Two birds were seen in a tamarack swamp, July 28.

38. *Contopus virens.* Wood Pewee. II. 1. An adult female was taken July 30. II. 2. Several were seen in open woodland. One nest was found July 23 in a tree, about 60 feet from the ground. VI. One was heard on the trail to Government Peak, July 26.

39. *Empidonax trailli alnorum.* Alder Flycatcher. IV. 2. Observed catching insects along the bank of Carp river. Several were seen in the alders along the river July 18. An adult male and female were taken July 22; these were among the willows when shot.

40. *Empidonax minimus.* Least Flycatcher. II. 1. Two were seen in a clearing in the arbor vitae swamp near the lake shore, and an adult male and female were taken July 27. IV. 2. Several were seen along Carp river, August 6, and two were seen in the alders along Carp river, July 18.

41. *Cyanocitta cristata.* Blue Jay. III. 5. Several seen at top of bluff July 23, and a female was taken July 17. IV. 3. Often seen along the river bank; an adult male shot July 18. VII. Several were seen at Little Carp Lake August 3, and one was seen August 7.

42. *Perisoreus canadensis.* Canada Jay. VI. One was seen near Little Carp Lake, August 7.

43. *Corvus corax principalis.* Northern Raven. I. Observed several times near Lake Superior. II. 3. One was seen flying over camp July 15, and one was heard August 12. One alighted upon the roof of the barn and was seen in the vicinity of the camp several times. III. Seen flying over the mountain top. III. 5. Often seen flying over the cliff, between July 5 and July 26. Adult males were taken, August 5 and July 30, on the cliff. Usually seen flying toward this cliff toward evening, about a dozen in a flock. IV. Was seen flying over the valley many times. V. Nine were counted flying over Carp Lake July 29. VII. One was seen at Little Carp Lake, August 2.

44. *Corvus brachyrhynchos.* American Crow. I. Common on the shore of Lake Superior. II. 3. One seen upon a dead tree near camp. III. 2. Observed flying overhead. III. 5. Common on the bluff July 15, and on July 18 several were seen on a dead pine. IV. 2 and 3. Often seen at the foot of the cliff, near the river, resting on tall tamaracks.

45. *Agelaius phoeniceus.* Red-winged Blackbird. IV. 2. Several were seen August 6, and on August 8 a young male was taken.

46. *Carpodacus purpureus.* Purple Finch. II. 1. Was often seen in the coniferous trees. An adult female was taken July 27. II. 3. "I found these very plentiful, and they did not appear to be paired. The males and females usually coming in separate flocks." (Peet). An adult male was taken July 14, and both sexes again July 15. These birds visited the camp for table refuse. IV. 2. Was seen feeding in the tamaracks August 3 and 4. VII. Observed at Little Carp Lake, August 2.

47. *Loxia curvirostra minor.* American Crossbill. II. 3. Adult male and female were taken at camp, August 5. These birds often came to camp to pick up crumbs. IV. 4. An adult male was taken August 4. A small flock was seen near the upper part of the river, August 5. Observed feeding among tamaracks, August 3 and 4.

48. *Loxia leucoptera.* White-winged Crossbill. IV. 4. Adult male and three females were taken August 5. The crops of these birds were full of tamarack seeds. VII. 2. A flock was seen at the beaver meadow, August 3.

49. *Spinus pinus.* Pine Siskin. II. 2. Common among coniferous trees July 13 and August 12. II. 3. A female came to camp and was seen to pick up some hair and fly away. Adult males were taken at camp, July 15 and 25, and August 9. The birds about camp showed little fear, and would fly within about three feet of one, to pick up crumbs. The males secured had very large testes. IV. 4. They were observed many times in the tamarack swamp August 3 and 4. VII. 2. Were seen near the beaver meadow, August 3.

50. *Pooecetes gramineus.* Vesper Sparrow. III. 2. Several were seen on the top of the mountain, August 10. III. 5. Several were seen on the top of the cliff on July 26; a large flock was also seen here August 3. They appeared to be migrating.

51. *Zonotrichia albicollis.* White-throated Sparrow. II. 2. An adult female was taken July 22 and an adult male August 5, in the hardwoods. II. 3. One was heard singing at dusk, July 18, in the clearing. IV. 2. One adult male was taken July 21 near Carp river, and an adult female was taken August 5. Often seen and heard singing towards evening along the river. IV. 4. Several were seen in a tamarack swamp July 28. VII. Several were seen at Little Carp Lake August 7. VII. 2. A number were seen at the beaver meadow, August 3. One was seen on the road from the Porcupines to Ontonagon August 14.

52. *Spizella socialis.* Chipping Sparrow. III. 2. An adult male was taken July 20. III. 5. Several were seen on the top of the cliff July 26, and a small flock on August 3. VII. Seen at Little Carp Lake August 2.

53. *Junco hyemalis.* Slate-colored Junco. III. 2. Abundant at all times on top of the cliff. Many were seen with insects, as if caring for young; they were always in the open or near the edge of a clearing (Peet). III. 5. On the top of the mountain a female was seen feeding young on July 27, and an adult female was taken July 17. VII. Observed at Little Carp Lake, August 2.

54. *Melospiza cinerea melodia.* Song Sparrow. II. 1. One was seen in a clearing near Lake Superior, July 25. II. 3. An adult female was taken, July 21, near camp. IV. 2. A young female was taken near Carp river. Adults were observed feeding fully fledged young, July 22.

55. *Melospiza georgiana.* Swamp Sparrow. IV. 2. Very common in the valley. Adult males were taken July 21 and 22, and young females July 28 and 31. The adults were observed feeding fully fledged young July 22. VII. 2. Observed at the beaver meadow, August 3.

56. *Zamelodia ludoviciana.* Rose-breasted Grosbeak. III. 5. One seen at the edge of the cliff July 23. IV. 2. One was seen in the alders July 23. A young male and female were taken in the tamaracks, August 5.

57. *Cyanospiza cyanea.* Indigo Bunting. II. 3. An adult female was taken while eating weed seeds in the clearing near camp, July 21. This was the only one seen.

58. *Piranga erythromelas.* Scarlet Tanager. III. 5. Adult male and female were seen July 15, and an adult male was seen July 26. VI. One was heard along the trail to Government Peak, July 26.

59. *Tachycineta bicolor.* Tree Swallow. VII. 2. One was seen at the beaver meadow, August 3.

60. *Ampelis cedrorum.* Cedar Waxwing. II. 1. One adult female was taken August 13; was frequently observed along the lake shore. II. 2. Seen flying overhead. II. 3. An adult male was taken July 19. These birds came repeatedly to the camp to pick up crumbs, etc. near the door of the shack. III. 2. Frequently seen on the top of the cliff and observed feeding on berries. III. 5. Several were seen July 26, along the edge of the cliff. Frequently observed at this locality, always in flocks. IV. 2. Very common along Carp river. An adult female was seen August 2 building a nest in the alders overhanging Carp river. VI. Several were seen at a small lake below Little Carp Lake on August 7.

61. *Vireo olivaceous.* Red-eyed Vireo. II. 1. Abundant at this station. II. 2. One was heard in the hardwoods July 14. An adult male was taken July 20. Several were seen with young just able to fly. II. 3. At camp an adult male was taken July 19, and young were taken July 15 and 20. These birds were common about camp, in the aspens. IV. 2. On July 22 one was seen singing in the alders. Abundant along the river. VII. 2. Seen near the beaver meadow, August 3.

62. *Vireo solitarius.* Blue-headed Vireo. II. 1. An adult male and female were taken July 27. IV. 4. Were seen in a tamarack swamp, and an adult male and female were taken August 5.

63. *Mniotilta varia.* Black and White Warbler. VI. The only one seen was on a small maple tree south of Carp river, August 5.

64. *Dendroica caerulescens.* Black-throated Blue Warbler. II. 2. A pair was found July 17, whose actions indicated a nest was near. A young bird in the down and an adult male were taken July 20. Several were seen on August 1. An abundant bird at this station, the young and adults were common in the hardwoods and usually in low brush. An adult female was taken July 16. II. 3. A female seen feeding young near the edge of a clearing July 20. II. 5. Many seen whose restless manner indicated a nest. Usually seen in young maples about four feet high. II. 2. Frequently in the low growth along the path in the hardwoods. IV. 2. Often seen in the bushes bordering Carp river. VI. Several males and females were seen in the vicinity of Little Carp Lake, August 7.

65. *Dendroica coronata.* Myrtle Warbler. I. Adults and young birds were seen in the brush near the shore of Lake Superior, July 16. III. 3. A young male was taken August 10. Several birds were seen in a flock among the tops of the Norway pines.

66. *Dendroica maculosa.* Magnolia Warbler. II. 1. A male was seen and a female taken July 21. Was always to be found among cedars near Lake Superior. Two were seen, August 1, on damp land quite thickly overgrown with bushes and tall grass. IV. 4. An adult male was taken July 21. Several were seen feeding in the tops of tamarack trees, and heard

singing July 28. On July 18 they were also observed in the tamaracks. VI. Seen near a stream on the trail to Government Peak July 26.

67. *Dendroica pensylvanica.* Chestnut-sided Warbler. IV. 2. An adult female was taken July 28, and several were seen near Carp river.

68. *Dendroica blackburniae.* Blackburnian Warbler. II. 1. A pair with two young were seen in the tops of birches, July 14. On August 1 several adults and young were seen in birches on marshy land. II. 2. Observed several times between July 13 and 30. II. 3. A female, with young in the down, were taken July 14. A young male was taken July 19. Several were seen near camp with young. II. 5. Small flocks of adults and young were seen several times feeding in the tops of young maples. IV. 3. Seen at the foot of the talus slope among the maple trees July 15.

69. *Dendroica virens.* Black-throated Green Warbler. II. 1. An adult male taken July 30, along the lake shore. II. 2. Common in the hardwoods; an immature male was taken July 20, and an adult July 18. III. 2. Several were seen feeding in the tops of Norway pines on the mountain top August 10. III. 5. Seldom seen at this station. A young male was seen here July 20. IV. 2. An immature male was taken August 5. Common among the alders along Carp river.

70. *Dendroica vigorsii.* Pine Warbler. III. 2. Seen carrying food to young in top of a Norway pine, at the edge of the cliff.

71. *Seiurus aurocapillus.* Oven-bird. II. 2. A nest containing two eggs and one young bird was found in the leaves near the path through the hardwoods, July 15. Young in nearly all stages of plumage were seen. Two were seen in the maple undergrowth, August 11, and a young male was taken July 21. II. 5. An adult male was taken in a trap set for mammals near the top of the bluff, July 15. Many young birds were seen, usually on the ground among the bushes, but sometimes running ahead in the path like quail (Peet). III. 2. Several were seen singly in the aspens bordering the bare mountain top. IV. 2. Seen several times among the alders along Carp river.

72. *Seiurus noveboracensis.* Water Thrush. IV. 2. Seen several times in the alders along Carp river, one was seen July 22. A bird was seen July 13 east of the Porcupines, on the road to Ontonagon.

73. *Geothlypis agilis.* Connecticut Warbler. II. 1. Adult females were taken July 27 and August 4. On July 27, four of these birds were seen in a marshy strip of land thickly overgrown with birch and long grass, but shaded with large hemlocks.

74. *Geothlypis philadelphia.* Mourning Warbler. II. Seen among the brush of open woodland, August 4. II. 3. A female and her young were taken July 15. An adult male was taken at the camp, July 14. Two females were seen, each with one young bird just able to flutter along in the low weeds. When the young were shot the females remained near by and kept up a sharp chirping and jerking movement of the body. Two males were taken, one of these appeared greatly excited when approached and flew from tree to tree among the young aspens, grasping the trunk of the trees so that its body was at right angle to the tree. They remained within about five feet of the ground (Peet). IV. 2. Was seen several times among the alders along Carp river and last seen August 5. VII. An adult and one young bird were seen among the brush on a bluff at Little Carp Lake, August 7.

75. *Geothlypis trichas brachidactyla.* Northern Yellow-throat. IV. 2. One was seen, scolding vigorously, in the brush near the boat landing, July

22, on Carp river. VII. 1. One was seen at Little Carp Lake, August 7 among the low brush growing on a rocky bluff over the lake.

76. *Wilsonia canadensis.* Canadian Warbler. II. 1. Seen several times among cedars along the Lake Superior shore, July 13-August 2. An adult female was taken August 2. IV. 2. An adult female was taken July 31 and again on August 2. One was seen July 15 with an insect in its bill and acted as if young were near.

77. *Setophaga ruticilla.* American Redstart. II. 1. An adult male was seen July 16, and several were observed in tall birches on July 17, near the Lake Superior shore. An adult male was taken July 17. IV. 2. An adult female was seen near Carp Lake, August 6. Many were seen in the brush along the river at various times. One was seen on the road to Ontonagon, July 14.

78. *Troglodytes aedon.* House Wren. II. 1. A young female was taken in a clearing July 25. There were several observed at this place in a dense brush pile. II. 2. A young male was taken July 24, in the hardwoods.

79. *Olbiorchilus hiemalis.* Winter Wren. II. 1. A small family was seen July 21, and a young male was taken July 23. Abundant at this station. IV. 2. An adult female and two young were taken August 10. Often seen among the alders along Carp river. VI. Several were seen near streams on the trail to Government Peak, July 26.

80. *Telmatodytes palustris.* Long-billed Marsh Wren. IV. 2. One male was taken near Carp river, July 22.

81. *Certhia familiaris americana.* Brown Creeper. II. 1. The first ones were seen July 13, but were frequently observed after that date. II. 2. A large flock of adults and young were seen among the hemlocks, July 15. An adult female and young were taken July 19.

82. *Sitta carolinensis.* White-breasted Nuthatch. III. 3. One was heard in the pines, July 20.

83. *Sitta canadensis.* Red-breasted Nuthatch. II. 1. This species was seen twice in the cedar swamps near Lake Superior, July 21 and 27. III. 3. One was seen, July 20, in the pines on the mountain top. IV. 4. An adult male and female, and two young males were taken July 27 in a tamarack swamp. Several were seen here again August 4. VI. One was seen near the beaver meadow August 3.

84. *Parus atricapillus.* Chickadee. II. 2. Adults were seen feeding fully fledged young in the aspens, along the path through the hardwoods, on July 15. Young were taken July 21. II. 3. A young bird was taken July 15, and an adult male and a young female were taken July 21. Often seen in the aspens about camp, usually with young which they were feeding. III. 5. Several were seen feeding in the Norway pines on top of the cliff, July 23. IV. 4. Several observed in a flock of Golden-crowned Kinglets in a tamarack swamp, August 11. VI. Quite common near Little Carp Lake on August 7.

85. *Regulus satrapa.* Golden-crowned Kinglet. II. 2. Young in the down taken July 2. Several seen in the hemlocks July 17. Abundant among the hemlocks, July 13 to August 12. Large flocks of young and adults seen in the tops of the tallest hemlocks on July 14. II. 3. Young birds were taken July 14 in the clearing. IV. 2. A young female was taken July 27. Several were seen with Chickadees August 11. Many were seen along the Carp river at various times. IV. 4. They were abundant in the tamarack swamps, August 4 and 5.

86. Hylocichla ustulatus swainsonii. Olive-backed Thrush. II. 1. An

adult female was taken July 22, with the tough thickened skin on the abdomen characteristic of a breeding bird. II. 2. Often seen in an open woodland, July 13 to August 12. III. 2. One specimen seen August 1. IV. 2. A young male taken July 29. The song was heard in the evening and morning in the woods at the foot of the cliff, but during the day the bird retired to the alders along the river valley. It stopped singing the last week in July. VI. A nest containing two eggs was found on the trail to Government Peak July 26.

87. *Hylocichla fuscescens.* Wilson Thrush. II. 3. Heard singing near camp during the evening of July 18. IV. 2. Young taken July 22 along Carp river.

88. *Merula migratoria.* American Robin. II. 3. An adult male was taken July 30, and another was seen near camp on August 10. III. 2. One was seen July 20. III. 5. An adult male was seen on the top of the bluff July 23. This is apparently a rare bird in the Porcupines.

89. *Sialia sialis.* Blue Bird. III. 2. Several seen near the edge of the cliff on August 10. III. 5. An adult female was taken July 19. "A nest was found in a Norway pine stub on the top of the cliff July 23. The old birds fed the young every 5 to 8 minutes during the half hour they were observed. The parents were quite tame as they fed the young while I stood within 15 feet" (Wood).

2. ISLE ROYALE.

The observations and records incorporated in the following notes were made at the southwestern or lower end of the Isle, in the vicinity of Washington Harbor. A few observations were also made in the vicinity of Siskowit Bay on the south coast. The time spent on the island covered the period from August 16 to September 5, 1904.

On account of the lateness of the season, but little could be determined concerning the breeding birds. The migrants were already abundant. This was evident on account of the abundance of the Chipping Sparrow, Sharp-shinned and Sparrow Hawks. Many of these migrating birds were so abundant and of such general occurrence that little could be learned of their habitat relations. Perhaps the limited extent of the island, as a feeding ground, emphasized the apparent abundance.

1. *Podilymbus podiceps.* Pied-billed Grebe. II. Two were seen on Washington river, August 17, and several more August 30. A young bird, in the first plumage, was taken August 18, and young birds were again taken August 24 and 25.

2. *Gavia imber.* Loon. VII. Two were seen on Lake Desor, August 24, and again August 30.

3. *Larus argentatus.* Herring Gull. VII. One adult was seen at Lake Desor on August 24. IX. The rocky promontories were often white with these gulls. They would swim about in the lake and then fly back to the rock. X. These birds were very abundant in the harbor, where they were seen every day. On August 19, a small island north of the mouth of Washington Harbor was almost completely covered with them. On August 31, flocks were observed feeding in the harbor.

4. *Merganser americanus.* American Merganser. II. A young female, in the down, and an adult, were taken August 31. An adult and five young were observed on Washington river, August 31. VII. A young bird, in the down, was taken August 21. X. An adult bird and several young were observed August 19.

5. *Querquedula discors.* Blue-winged Teal. II. Three were seen on Washington river August 30. X. A flock of 25 or 30 were seen in the harbor August 30.

6. *Botaurus lentiginosus.* American Bittern. II. One was seen flying along the river on August 24 and again on August 30.

7. *Ardea herodias.* Great Blue Heron. I. One was seen flying over camp, August 21. X. One was seen flying over the harbor on August 30.

8. *Porzana carolina.* Sora. II. One was seen near the margin of the river August 22. Adult males were taken on both August 24 and 25. One was again observed at the edge of the river in tall grass, August 28; also observed on August 30, near the river.

9. *Fulica americana.* American Coot. II. One was seen August 22 on the river, and an adult female was taken August 24.

10. *Gallinago delicata.* Wilson's Snipe. I. One seen August 17 and 25 near the harbor.

11. *Actodromas minutilla.* Least Sandpiper. X. One seen August 28 and September 4, along the shore of Washington Harbor.

12. *Totanus flavipes.* Yellow-legs. I. An adult female was taken August 26 from a small flock which came into the clearing at the house. X. One was seen on the dock in the harbor, August 25.

13. *Helodromas solitarius.* Solitary Sandpiper. II. An adult male was taken August 17, a female August 18, and a young bird September 3. It was common along Washington river August 17 to September 3. X. Several were seen at the edge of the harbor September 4.

14. *Actitis macularia.* Spotted Sandpiper. X. One was seen on the shore at Washington Harbor, August 28.

15. *Pediocaetes phasianellus.* Sharp-tailed Grouse. I. A resident reports that "prairie chickens" come to the clearing in the fall. VIII. Several were seen in a clearing at Siskowit Bay, August 29. This was the only species of grouse seen on the island by the party.

16. *Accipiter velox.* Sharp-shinned Hawk. I. Very abundant. Young males were taken between August 16 and 31, and young females August 21, 23 and 31. One adult female was taken August 27. Several were seen every day about the camp and in the clearings along the river. "Very abundant in clearings, showing little fear until fired upon repeatedly. They were very ferocious; one caught a Sora Rail while on the wing, and tore it to pieces within 15 feet of me. It grasped its prey from beneath by darting under it, turning over, and thrusting its claws into its victim's breast" (Peet). VII. One was seen at Lake Desor, August 24.

This was an abundant bird from August 17 until September 3, and showed a decided preference for clearings and open woodland, where it found several kinds of sparrows and warblers, in whose company it seemed to migrate.

17. *Accipiter cooperii.* Cooper's Hawk. X. One seen over the harbor. "This bird flew over the boat as I was fishing on August 19" (Wood).

18. *Buteo borealis.* Red-tailed Hawk. I. One was seen flying over camp, August 28.

19. *Buteo lineatus.* Red-shouldered Hawk. II. One was seen September 4.

20. *Haliaetus leucocephalus.* Bald Eagle. X. A fine adult was seen at Washington Harbor, August 16. An adult bird was perched upon a stump near the water's edge, at the mouth of Washington river, on August 27. On August 31, this eagle was again seen. A resident reports

that its mate was killed last year, and that the pair had lived here for many years (Wood).

21. *Falco columbarius.* Pigeon Hawk. I. An adult female was taken August 30. One was seen near the camp on August 31 and September 1. II. An adult male was taken August 23, and two were seen September 1.

22. *Falco sparverius.* American Sparrow Hawk. I and II. Adult males were taken August 16 and 23, adult females August 23 and 27. This was the most common hawk frequenting the clearing about the harbor. Observed catching grasshoppers in the clearings. Several were caught in steel traps baited with meat. Observed in abundance from August 16 to September 5.

23. *Pandion haliaetus carolinensis.* Osprey. II. An adult female was taken August 26, and one was seen August 25. X. One was seen over the harbor on August 20.

24. *Asio accipitrinus.* Short-eared Owl. I. One was seen at the edge of the clearing August 17, and one was found dead near the camp on August 16. This species was not seen after August 17. It probably migrated (Wood).

25. *Asio magellanicus occidentalis.* Great Horned Owl. II. Three were seen August 22 near the river. Near by, in a clearing, four were found about dark August 26, and three were taken.

26. *Ceryle alcyon.* Belted Kingfisher. II. One or two were seen nearly every day from August 16 to September 1, along Washington river. An adult female was taken August 26. They were occasionally seen pursued by Sharp-shinned Hawks. When the hawk was nearly upon it, the Kingfisher would throw up its bill and ward it off, in a manner similar to that stated for herons when pursued by hawks (Peet). VII. One was seen at Lake Desor on August 24. X. Occasionally seen along the harbor.

27. *Dryobates villosus leucomelas.* Northern Hairy Woodpecker. I. One was seen September 1. II. One was seen August 16 and again on 19. III. Adult females were taken August 20 and on September 1. IV. Two were heard along the creek in the cedar swamp, August 4.

28. *Dryobates pubescens medianus.* Downy Woodpecker. I. A young male was taken August 29. IV. An adult male was taken August 18. VII. Seen at Lake Desor, August 24. A common bird of general distribution.

29. *Picoides arcticus.* Arctic Three-toed Woodpecker. II. An adult female was taken, August 31. One was seen each day August 28, 29 and 30. This was a rare bird in the vicinity of Washington Harbor.

30. *Sphyrapicus varius.* Yellow-bellied Sapsucker. II. A young female was taken August 22, along Washington river, in the coniferous forest. Apparently a rare bird in this vicinity.

31. *Coephloeus pileatus abieticola.* Northern Pileated Woodpecker. II. and III. An adult male and a young female were taken August 19. An adult male was taken August 30, and five other birds were seen. Quite common in the forest and were heard or seen almost every day. "One specimen, after being shot at, was called back by continued clapping of the hands, although under other circumstances, they are very shy and difficult to approach. On rainy mornings they were very noisy" (Peet). "They were very noisy in the morning about sunrise, but on cloudy days they continued their pounding and calling for several hours" (McCreary).

32. *Colaptes auratus luteus.* Northern Flicker. II. Very abundant in the clearings along Washington river. One was shot August 16. VII. One was seen September 3 at Lake Desor.

33. *Chordeiles virginianus.* Night Hawk. I. Young females were taken August 16, and an adult male was taken August 23. A very common bird, frequently seen in the evening catching insects over the grass and water. Found roosting on the ground in clearings. None were observed after August 29.

34. *Chaetura pelagica.* Chimney Swift. I. Several were seen flying overhead on August 16, 17, 19 and 23, at the camp clearing.

35. *Trochilus colubris.* Ruby-throated Hummingbird. I. It was reported, as have been seen hovering about flower beds at the camp clearing. II. One was seen August 30 along the road through the coniferous forest.

36. *Sayornis phoebe.* Phoebe. I. An adult male was taken August 26 near camp. II. An adult female was taken August 18 and others were seen, at various times, between August 17 and 28, along the road in or near clearings.

37. *Nuttallornis borealis.* Olive-sided Flycatcher. I. Occasionally seen on dead trees in the clearings. II. An adult male was taken August 18, and was common from August 17 to August 28. IV. Seen on August 18 in a cedar swamp.

38. *Empidonax minimus.* Least Flycatcher. II. Often seen between August 19 and September 3. III. An adult male was taken August 31. Common.

39. *Cyanocitta cristata.* Blue Jay. II. An adult male was taken August 19, and a young female August 18. Very common about the deserted mining camps. Seen August 22 and 28, along the road. Adults moulting.

40. *Perisoreus canadensis.* Canada Jay. II. An adult male and female were taken August 25. Found about the deserted mining camps. Adult males were seen August 18, 22, and September 1, and females August 19 and 23. A common bird. VII. A number were seen at Lake Desor, August 24. They were very quiet and were not seen until we started to fry our bacon in front of the tent. Several then came flying from different directions and perched on the spruce boughs just above us, hopping about until we left camp, when they flew down about the ashes in search of scraps. (Ruthven).

41. *Corvus corax principalis.* Northern Raven. I. An adult female was taken August 23. II. On several mornings a flock of six was seen in a clearing. One was shot August 17. X. Eight were seen August 19, near the entrance to Washington Harbor; on August 30, three were seen flying over the Harbor. Reported to be a resident bird. The adult specimens taken were moulting.

42. *Corvus brachyrhynchos.* American Crow. I. This species was not as common about the clearing as were the Ravens, and was much more shy. Early in the morning of September 4, one came to the clearing and perched on the roof of an old log house, a few rods from camp. II. Two were seen nearly every day along the river.

43. *Agelaius phoeniceus.* Red-winged Blackbird. I. An immature female was taken August 26.

44. *Agelaius phoeniceus fortis.* Northern Red-winged Blackbird. I. Young males were taken August 18 and 26, and an adult female was taken on August 29. II. Several flocks (species uncertain) numbering about 15 or 20 specimens, were seen in the clearing. Only one male in black plumage was seen. Common. VII. An adult female was taken on August 24.

45. *Quiscalus quiscula aeneus.* Bronzed Grackle. II. An adult female

was taken August 19 in the clearing along the river. This was the only specimen seen and was found feeding in front of a deserted cabin.

46. *Loxia leucoptera.* White-winged Crossbill. II. Only small flocks were seen August 18, 26 and 30. IV. A small flock was seen on August 18.

47. *Astragalinus tristis.* American Goldfinch. II. A flock was seen August 19, and several were seen on August 17.

48. *Spinus pinus.* Pine Siskin. II. Frequently seen in flocks between August 18 and September 5.

49. *Passerculus sandwichensis savanna.* Savanna Sparrow. I. Young males were taken August 17 and 26, and adult females were taken August 30, and 31. This species was seen in flocks all over the clearing about camp, and was very tame, even coming into the houses. Very common after August 26 along roads and in the clearings. During the last week in August this species became abundant and was very tame. After September 1 it began to leave and nearly all were gone by September 5.

50. *Zonotrichia leucophrys.* White-crowned Sparrow. II. Two specimens were seen near the deserted mining camps September 1. On August 29 two were seen along Washington river. One was taken August 28.

51. *Zonotrichia albicollis.* White-throated Sparrow. I. One was seen at the edge of the clearing on August 24, and on September 1 and 4. II. An adult female and a young male were taken August 19. Young and the adults were seen almost every day along the river. VII. One was heard at Lake Desor on August 24.

52. *Spizella socialis.* Chipping Sparrow. I. Young males were taken August 17 and 27, and young females August 24 and 27. Very common in the camp clearing. II. Abundant in the clearing.

53. *Spizella pallida.* Clay-colored Sparrow. I. An adult male was taken August 25, and one was seen August 26. II. One was seen each day on August 28 and 31, in the clearing.

54. *Junco hyemalis.* Slate-colored Junco. I. An adult male was taken August 29. II. It was very common in the clearings between August 28 and September 5.

55. *Melospiza cinerea melodia.* Song Sparrow. I. One was seen August 24. II. Common from August 17 to 28, among brush in the clearings.

56. *Melospiza lincolnii.* Lincoln's Sparrow. II. An adult male was taken September 1, in the undergrowth of a white cedar swamp.

57. *Ampelis cedrorum.* Cedar Waxwing. I. A young male was taken and a flock was seen August 18. II. Several were frequently seen along Washington river. Several nests were found August 28 in alders about six to ten feet from the ground. These nests had recently been used (Wood). An old bird was seen feeding four young that had just left the nest, September 1. An abundant species.

58. *Vireo olivaceus.* Red-eyed Vireo. II. Adult males were taken August 23 and September 5.

59. *Vireo philadelphia.* Philadelphia Vireo. II. One was seen September 1, along the road through the coniferous forest.

60. *Mniotilta varia.* Black and White Warbler. II. One was seen August 24 (Wood).

61. *Helminthophila rubricapilla.* Nashville Warbler. II. One was seen August 28. IV. A young male was taken August 18.

62. *Helminthophila peregrina.* Tennessee Warbler. I. An adult male was taken August 22 and a young male September 4. II and III. Three birds were seen August 24. Very common in woodland. Not seen before

August 22, after that date they were quite common until September 4. Evidently a migrant.

63. *Dendroica caerulescens.* Black-throated Blue Warbler. II and III. An adult male was taken August 17. A male and female were seen August 25 and one was seen August 24. Common, a few seen nearly every day from August 17 to September 4.

64. *Dendroica coronata.* Myrtle Warbler. I. A young male was taken August 29. II and III. An adult female was taken September 3. A few seen nearly every day from August 20 to September 3. Apparently migrating. Common.

65. *Dendroica maculosa.* Magnolia Warbler. II. An adult male was taken August 30, and an adult female September 3.

66. *Dendroica striata.* Black-poll Warbler. I. A young male was taken August 26, and two were seen September 4, near the camp. II. Young males were taken August 26 and 30.

67. *Dendroica virens.* Black-throated Green Warbler. II and III. One seen on August 24, and three on August 25. Seen every few days between August 18 and September 3. An adult male was taken September 1. Of general occurrence. Common.

68. *Dendroica palmarum.* Palm Warbler. I. An adult male was taken August 26 and September 4, and a young male was taken August 29. Many were seen at camp September 4, and were quite tame. These birds were abundant in the clearing about camp and even came close to the house, September 1. Generally found in bushes along clearings. During the night of September 3, a wave of this species occurred, and in the morning of September 4, large numbers of these birds were observed in the brush in the clearing, some specimens even coming about the camp.

69. *Seiurus aurocapillus.* Oven Bird. II. One was seen August 24. VII. An adult female was taken August 24.

70. *Seiurus noveboracensis notabilis.* Grinnell's Water Thrush. I. An adult male was taken August 26. II and III. One was seen on each of the following dates, August 18, 22, 24, 28 and 31. An adult female was taken August 24. IV. On September 1, one was heard singing a low sweet song in a cedar swamp. (Wood).

71. *Wilsonia pusilla.* Wilson's Warbler. II. An adult male was taken August 30, in alder bushes near a small stream. Evidently a migrant.

72. *Setophaga ruticilla.* American Redstart. I. Several were seen August 24, 27 and September 4. II. A young male was taken August 17. A few were seen every few days from August 17 to September 4.

73. *Olbiorchilus hiemalis.* Winter Wren. II and III. Individuals were seen August 20, 25, 30 and September 1, 3, and 4. A young male was taken August 31. IV. "An adult female was taken September 1 in a dense cedar swamp. I awakened her curiosity so much by making a chirping sound that she hopped upon a bush in full view thus allowing a chance to secure her." (Wood).

74. *Certhia familiaris americana.* Brown Creeper. II. One was killed August 19 and one seen August 20, and 22.

75. *Sitta carolinensis.* White-breasted Nuthatch. VII. An adult male taken August 24 among birch trees on the hillside.

76. *Sitta canadensis.* Red-breasted Nuthatch. II, III and IV. Adult females were taken August 17, 18 and 25. Many were seen almost every day between August 16 and September 5. VII. Abundant August 24. *A very abundant* bird of general distribution in the forest.

77. *Parus atricapillus.* Chickadee. II, III and IV. An adult male was taken August 17. Many were seen almost every day between August 16 and September 5. VII. Abundant August 24. Very abundant, of general distribution in forests.

78. *Regulus satrapa.* Golden-crowned Kinglet. II, III and VI. It was often seen feeding in spruce and balsam trees in company with the Chickadee and Red-breasted Nuthatch. Many were seen almost every day between August 16 and September 5. VII. Abundant at Lake Desor, August 24. Abundant and of general distribution in the forest.

79. *Regulus calendula.* Ruby-crowned Kinglet. II. An adult female was taken August 28, and one or two were seen on each of the following days, August 29, 30, and September 3 and 5.

80. *Hylocichla ustulatus swainsonii.* Olive-backed Thrush. II and III. An adult male was taken September 1, and a young male on August 24. Some were seen every few days in underbrush, they were very shy.

81. *Merula migratoria.* Robin. I. One was seen on August 16. II. One was also seen along the river on August 23.

NOTES ON THE MAMMALS OF THE PORCUPINE MOUNTAINS AND ISLE ROYALE, MICHIGAN.

CHAS. C. ADAMS.

The specimens obtained by the expedition were largely collected and prepared by Max Minor Peet assisted by N. A. Wood. Mr. Wood secured the series of notes from Mr. Haring, a former fur dealer, concerning early mammal records. Other members of the party, A. G. Ruthven, O. McCreary and W. A. Maclean, also contributed notes, specimens or both.

I take pleasure in expressing our obligations to Dr. C. Hart Merriam, Chief of the Biological Survey of the U. S. Department of Agriculture, for kindly determining a representative series of specimens, and for the determinations made by Mr. W. H. Osgood of the same Survey; also to Dr. Glover M. Allen of the Boston Society of Natural History, for valuable suggestions and for the determination of the deer and bats. The other specimens collected have been named by a careful comparison with the determined series.

1. PORCUPINE MOUNTAINS.

1. *Odocoileus virginianus borealis* (Miller). Northern Virginia Deer. Near Station II. 2, but on Section 15, an adult male was taken in the hardwood forest, August 1, and a fawn, August 14, on Section 18. V. 2. "After sundown a deer came down into the marsh at the east end of Carp Lake, also a young buck about a year old, and later on a doe with a small fawn" (Maclean). VII. 1. "After sundown, August 3, nine deer were seen about the margins of Little Carp Lake, where they were feeding on the grasses and sedges. During September, 1903, deer were often surprised during the night, standing in the water at the margin of Carp Lake. Trappers reported that the flies were especially abundant this year" (Ruthven). During the past season this habit was not observed. Trappers reported that flies were not abundant owing to late spring frosts, and attributed the absence of the deer from the lake, during the night, to this cause.

2. *Sciurus hudsonicus loquax* Bangs. Southeastern Red Squirrel. II. 1. Two adult females were taken. August 21 and 28, in the cedar swamp. IV. An adult male was taken July 29.

3. *Tamias striatus lysteri* (Rich.). Northeastern Chipmunk. II. 2. An adult female was taken August 10. III. 4. A male was taken July 20. II. 3. On July 20, an adult male was taken at the camp clearing. IV. 3. August 2, an immature male was taken in the hardwood forest of the river valley.

4. *Eutamias quadrivittatus neglectus* (Allen). Lake Superior Chipmunk. II. 1. Seven specimens, young and adults of both sexes, were taken between July 21 and August 12, at the edge of a cedar swamp and along the Lake Superior shore. VII. 1. An adult female was taken, August 11, on a rocky bluff on Little Carp Lake.

5. *Marmota monax* (Linn.). Woodchuck. II. 2. An adult female

was taken July 28 (No. 32139). This is a very dark specimen when compared with the normal form found at Ann Arbor, Mich. The long over hair, especially on the top of the head, the rear of the back and the tail, is very dark brown or black. The pale under fur is also darker than in normal specimens. The hair on the lower parts of the body is much more rufous and darker than in the normal form. II. 3. In the camp clearing, an adult and one young of the normal color were seen.

6. *Sciuropterus sabrinus* (Shaw). Northern Flying Squirrel. II. 2. Two adult females were taken in the hardwood forest, August 3 and 4. III. 5. In the aspen zone near the mountain top, an adult female was taken July 29.

7. *Castor canadensis* Kuhl. American Beaver. IV. 1. Old beaver dams were observed on Carp river, and relatively fresh ones on Little Carp river, VII. 3, by Ruthven. Mr. David Allie, of the Carp Lake Mine, reported that the last beaver taken on Carp river was about 1898. VII. 3. No fresh signs of beaver were observed on Little Carp river. Allie reported them to occur on the river below Little Carp Lake. Beaver cuttings were secured from the dams on Carp and Little Carp rivers.

8. *Peromyscus canadensis* (Miller). Canadian White-footed Mouse. II. 2. Four males taken August 3, 11, and 13, were referred to *canadensis* by the U. S. Biological Survey. Two males taken August 8 (No. 32193) and August 6 (No. 32197), and an immature male taken July 24 (No. 32198), apparently belong here. This was one of the most common mammals in the mountains.

9. *Evotomys gapperi* (Vigors). Common Red-backed Mouse. II. 2. Two males were taken in the hardwood forest, August 3 and 13. III. 5. Two pair of adults were taken in the aspen zone bordering the mountain top between July 22 and 30. IV. 4. Two adult females were taken August 6 and 7, in the tamarack swamp.

In the Porcupines this mouse is thus seen to frequent a variety of habitats, the hardwood forest, the aspen zone, and the tamarack swamp. Farther south it is more closely restricted to cool swamps.

10. *Fiber zibethicus* (Linn.). Muskrat. IV. A few specimens were seen along Carp river, July 16, by Maclean and McCreary. VII. 1. One specimen was shot at Little Carp Lake, August 7, by Peet.

11. *Zapus hudsonius* (Zimm.). Northern Jumping Mouse. II. 2. An immature male was taken, July 30, in the hardwood forest. VII. 1. An immature male was taken on a rocky bluff along Little Carp river, August 11.

12. *Napæozapus insignis* (Miller). Woodland Jumping Mouse. II. 2. Three adult males were taken in the hardwoods, between August 4 and 13.

13. *Erethizon dorsatum* (Linn.). Canadian Porcupine. II. 2. An adult female and a pair of young were taken in the hardwood forest between July 23 and August 8. An adult male was shot, July 13, in the hardwood forest near the base of the mountain slope. II. 3. Three females were taken, during July, in the camp clearing. IV. 1, and V. 1. Porcupines were frequently seen, by Ruthven, in the river and lake both during the day and night, eating leaves of the yellow water lily. (This habit is shown in Fig. 19).

This interesting animal was very abundant and of general distribution in the forest.

14. *Lepus americanus virginianus* (Harlan). Southern Varying Hare. II. 3. An adult female was taken, August 9, in the camp clearing. It had evidently been suckling young and was in full summer pelage. The yellowish rufous pelage is much more marked than in the Hares from Isle Royale

(var. *americanus*). The white outer ear margin is only feebly developed. IV. 2. A young female was taken, Aug. 21, in the alders along Carp river. In this specimen the rufous tints are very pronounced on the upper side of the legs and on the pectoral region. The outer margin of the ear is of a distinctly yellowish white color.

15. *Lynx ruffus* (Gueld.). Bay Lynx; Wild Cat. IV. 2. A weathered skull was found in the alder bushes along Carp river, by Ruthven. Trappers reported this species common.

16. *Canis occidentalis* Richardson. Gray Wolf. The trappers reported them common. Near the Porcupines, during the winter of 1902-'03, a trapper was reported to have been treed by a pack. Wolves are reported to have killed many deer near the Porcupines, during the past winter of 1904-'05.

17. *Taxidea taxus* (Schreber). Badger. Trappers reported that occasionally specimens were found.

18. *Mephitis hudsonica* (Rich.). Northern Plains Skunk. II. 3. Young and three adults of both sexes were secured between July 15 and July 30, in the clearing about camp. They were very abundant. A large adult male was taken, July 30, which weighed eight pounds. II. 2. Two specimens were seen by Ruthven along the road through the hardwood forest in September, 1903. On the morning of July 15, Wood found a young skunk in a trap, held fast by the foot. Another of about the same size was observed running about the captive, making frequent attempts to liberate it by biting the trap and pulling with its fore feet.

The skunks found in the traps were not at all violent in their attempts to escape and could easily be approached and killed with a noose.

This is a northern plains and Rocky Mountain species. These northwestern affinities suggest an origin from that direction, by way of Minnesota.

19. *Putorius cicognani* (Bonap.). Small Brown Weasel. Near II. 2. An adult female was taken along a corduroy road through the hardwoods on Section 17. Dr. Merriam wrote in 1896, "It probably also occurs in Northern Michigan and Wisconsin." (N. A. Fauna No. 11, p. 11).

20. *Ursus americanus* Pallas. Black Bear. III. Fresh signs were observed several times on the mountain top, where Allie reports that they often came to feed upon the dwarf and low black blueberries. A cub was observed here, August 5, by Allie.

Trappers reported them quite common in the mountains. An adult bear was killed, July 11, 1904, at Iron river, near the Porcupine Mountains.

21. *Sorex hoyi* Baird. Hoy's Shrew. III. 5. A pair of adult specimens were found in the aspen zone on the mountain on July 29, and August 2. IV. 4. One specimen was taken, August 12, in the tamarack swamp.

This is said to be the smallest North American mammal, and is without doubt the smallest one in Michigan.

22. *Blarina brevicauda* (Say). Large Bob-tailed Shrew. II. 2. Adult shrews of both sexes were taken in the hardwoods during August. II. 3. Three adult females were taken in the clearing. III. 5. Adults of both sexes were taken in the aspen zone surrounding the mountain top.

This shrew and the White-footed Mouse were the most common small mammals in the mountains.

23. *Condylura cristata* (Linn.). Star-nosed Mole. II. 2. A pair of moles was taken, September 2, 1903, by Ruthven, in the hardwood forest, on the mountain slope above the camp. This was about 800 feet above lake level. The line of their tunnel was intersected by a cutting, at the base

of which was an old ore bucket into which they had apparently fallen and drowned. Farther south these animals are closely confined to swamp land.

24. *Myotis subulatus* (Say). Say's Bat. II. 3. Three adult males were taken in camp, August 13, by Peet.

Supplementary Notes.

The following notes were secured by Mr. Wood from Mr. C. E. Haring of Ontonagon, Michigan. Mr. Haring and his brother bought furs from the Indians and trappers between 1860 and 1875. Unless otherwise specified these records refer to Ontonagon County.

Caribou. He had no authentic record of this species.

Moose (Alce). A moose was taken at Union Bay in 1864, and one at Gogebic Lake, Gogebic County in 1863.

Deer. Are more abundant now than formerly.

Beaver. Was yet common in 1860.

Canada Lynx. Was twice as abundant as the Wild Cat. At the present time this species is rare.

Wild Cat. Common.

Panther. Had no experience with them but had heard authentic reports of their occurrence before 1860.

Wolf. Was very common and killed many deer.

Red Fox. Was common; cross fox rare, and silver gray fox very rare.

Otter. Several skins were secured each year about 1860.

Wolverine. At Rockland, five were bought by his brother, J. M. Haring, between 1865 and 1875. This is the only Michigan (?) locality known to the writer. Of course the animals may not have been killed near Rockland, but may have come from a distance. Hon. Peter White, of Marquette, informs me, that, although he has made inquiry for many years, he has been unable to obtain authentic records of the Wolverine in Michigan.

Fisher. Common in 1860; a few skins secured each year.

Martin. Very common in 1860. A few have been taken in recent years.

Mink. Common.

Racoon. A very few have been taken.

2. ISLE ROYALE.

1. *Rangifer caribou* (Gmelin). Woodland Caribou. An Indian trapper reported that fresh tracks were seen during July, 1904, in a clearing near Siskowit Bay.

2. *Sciurus hudsonicus* Erx. Hudson Bay Red Squirrel. II. Nine specimens were taken in the coniferous forests, both young and adults. The resin on the hair about the mouth shows that both young and adults feed upon the coniferous seeds. Two of the specimens are old females which have reared young, as shown by the scanty hair on the belly; in both, four nipples had been functional. III. A young and adult male were taken in the deciduous forest along the Lake Desor trail.

There is considerable variation in the color of the upper side of the tail in the Isle Royale specimens. The median rufous band is quite pronounced in two specimens.

A winter skin, taken by a trapper, lacks the distinct lateral black line, found in the summer specimens and has a faint rufous stripe extending from the ears to the subterminal black bar on the tail. The shorter tails, with

much less rufous, and the gray color contrast these squirrels with those from the Porcupine Mountains (var. *loquax*).

Mr. Wood frequently saw squirrels feeding upon seeds taken from the cones by first cutting away the lower scales.

3. *Peromyscus canadensis* (Miller). Canadian White-footed Mouse. I and III. Two specimens, both adult females, one from the camp clearing and the other from the Lake Desor trail were determined by the U. S. Biological Survey as of this species. Two immature males, from II, were doubtfully referred to this species, also a male from III. Four specimens, of both sexes, taken at II, are provisionally referred to this species.

4. *Fiber zibethicus* (Linn.). Muskrat. II. A pair of muskrats were taken along the creek through a cedar swamp, other specimens were seen but not taken.

No. 32117. August 29. l. 465., t. 216., h. f. 66. M. M. Peet,
No. 32118. August 24. l. 436., t. 250., h. f. 64. collector.

5. *Lepus americanus* Erx. Hudson Bay Varying Hare. II. Six specimens were taken among the conifers between August 18 and 22. The pelage of three of the specimens is long and loose, the tips of the long hairs on the back are white or very pale yellow; the white hairs give the head a frosted appearence. These are young specimens. The pelage of the other three is more compact, and black hairs are more conspicuous, the upper part of the head is a pale yellowish brown. An adult female, No. 32131, is the largest specimen, and also the darkest; a black mid-dorsal band is fairly distinct. The white outer margin of the ears is very wide and distinct. The upper part of the hind legs is mottled with white and yellow hairs; long, scattered white tipped hairs occur on the end of the body above the tail.

The distinctness of the outer white ear margin varies in this series. The large female, mentioned above, has very long white hair; the three specimens first mentioned, have quite white hair, while in two others the hair is yellowish white.

It is interesting to note that these are a different variety from that found in the Porcupine Mountains, on the south shore (var. *virginianus*). This, like several other members of the biota, shows the close affinities of the Isle Royale types to the adjacent mainland rather than to the remainder of Michigan.

6. *Lynx canadensis* (Kerr). Canada Lynx. Mr. Wood made the following note on lynx skins which he saw at the Washington Club House, at Washington Harbor. "I saw two Lynx skins taken by Chas. Preulx during the winter of 1903 and 1904. Preulx says that this is the only species he has seen on the Island."

7. *Mustela americana* Turton. Eastern Martin. "Mr. Preulx had several martin skins which were taken during the winter of 1903-'04, on the maple ridge, not far from Washington Harbor. These skins were very dark brown with a few scattered white hairs, especially on the under side." (Wood).

8. *Putorius vison* (Schreber). Mink. II. Mr. Wood found a dead specimen in a barrel sunk at a spring. Preulx reported it quite common about the Harbor and along the streams.

9. *Putorius cicognani* (Bonap.). Small Brown Weasel. Mr. Wood reports that Preulx had about 10 skins, and said they were quite common.

10. *Putorius noveboracensis* Emmons. New York Weasel. Preulx had a number of large weasel skins which probably belonged to this species.

11. *Myotis lucifugus* (LeConte). Little Brown Bat. I. One specimen was taken, September 1, by Peet. Wood reports seeing a bat on wing August 22. These were the only bats seen on the island.

No specimens of the Red-backed Mouse, (*Evotomys gapperi*), were taken although they have been reported from Isle Royale by Coues (Mong. N. American Rodentia, p. 145). Of special interest to the student of the Isle Royale fauna is Miller's "Notes on the Mammals of Ontario," (Pro. Bost. Soc. Nat. His., 1897, Vol. 28, pp. 1-44).

This collection from Isle Royale, although a small one, is of interest in several respects. The Isle, it should be remembered, is 45 miles long with a maximum width of 8½ miles, and is about 15 miles from the Canadian shore. As might be anticipated, the affinities of the mammal fauna are with those of the north shore of Lake Superior rather than with those of the south shore. This is shown by the occurrence of the Caribou, Red Squirrel, Varying Hare and, perhaps, the White-footed Mouse.

It should also be borne in mind the relatively recent or postglacial origin of this island fauna. Since the advent of the present fauna we have no reason to believe that this island has ever been connected with the mainland. In other words, the fauna and flora must have reached their present location through the agency of winds, waves, lake currents, over the ice, and, possibly, in the case of some forms, through the influence of man.

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GEOLOGICAL REPORT

ON

BAY COUNTY

BY

W. F. COOPER

Michigan Geological Survey

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1906

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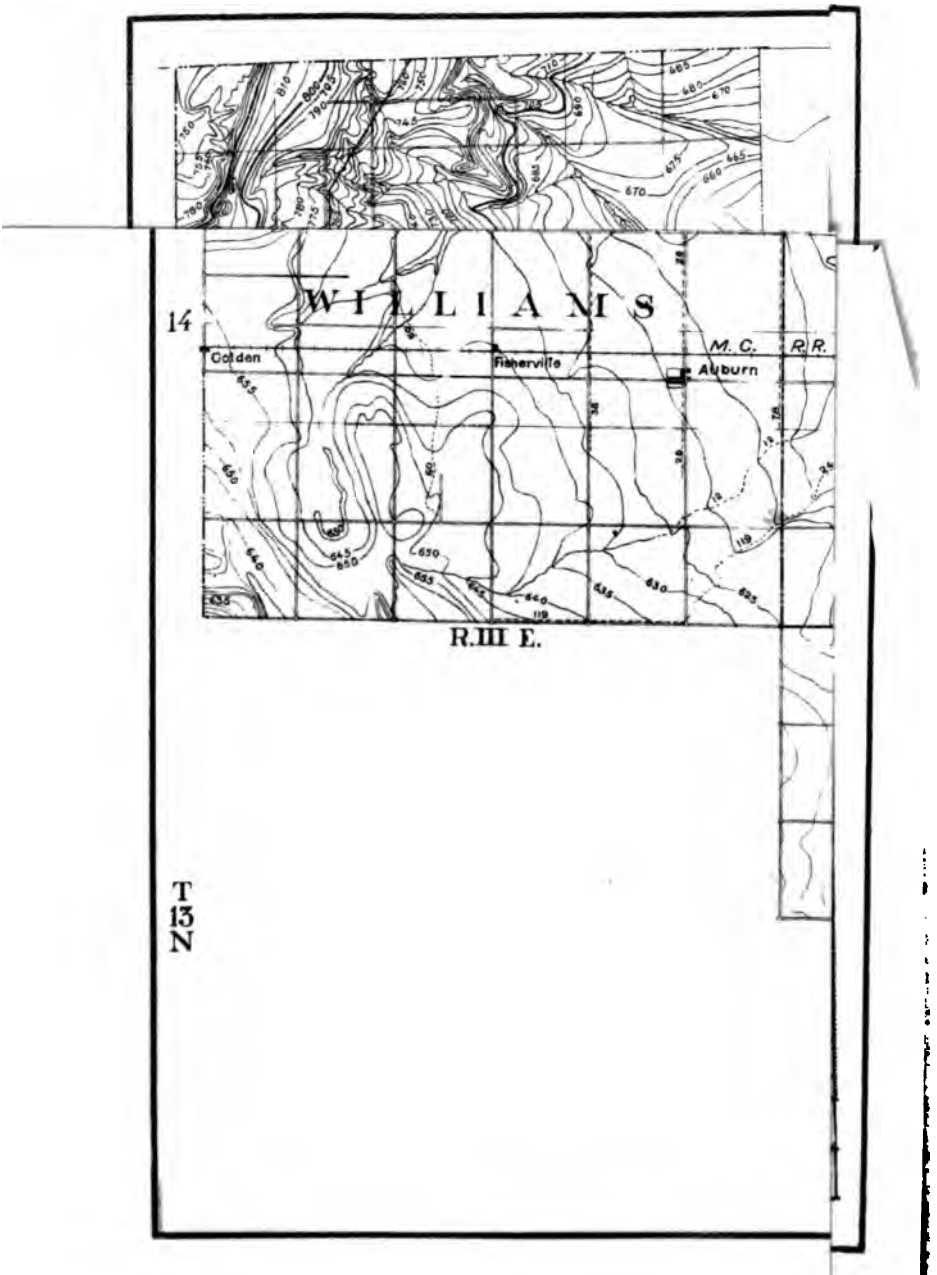
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LETTER OF TRANSMITTAL.

OFFICE OF THE STATE GEOLOGIST,

LANSING, MICHIGAN, Jan. 22, 1906.

To the Honorable, The Board of Geological Survey of the State of Michigan:

Hon. Fred M. Warner, President.

Hon. W. J. McKone.

Hon. Patrick H. Kelley, Secretary.

Gentlemen:—I herewith transmit for publication as part of your report for 1905, the following report on Bay county by W. F. Cooper. It represents a great deal of work on his part in compiling lines of levels and records of coal exploration, and I trust may be of service to the people of that county, especially in the development of the coal. The salt industry and bromine which might be developed in connection near the west line of the county, cannot satisfactorily be treated by counties. The full notes of the various drain lines, which he found in various hands and compiled, I have however, omitted, as they would be of interest to so few, to avoid undue expense, but they may be consulted in my office, or in that of the Bay County Drain Commissioner.

Very respectfully,

ALFRED C. LANE,

State Geologist.

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CHAPTER I.

HISTORICAL, INTRODUCTION.

1. *Position.*

Bay county, appropriately named from its situation on the western and southern shore of Saginaw Bay, is further bounded on the east by Tuscola county, situated at the base of the "Thumb" of Michigan, on the south by Saginaw county, on the west by Midland and Gladwin counties, and on the north by Arenac county. Bay City, which is situated in the southern part of the county, is in longitude 80° 50′ west, and latitude 43° 36′ north, as given on the chart of the U. S. Lake Survey.

It embraces in the U. S. Government Linear Survey, nine full and seven fractional townships, the latter being along the shore of Saginaw bay with the exception of Frankenlust township, which is in the southern part of the county. Townships 13 to 18 north and ranges 3 to 6 east fall within its limits.

2. *Area of Bay County.*

The area as determined by a planimeter, from the Government township plats in the office of the Land Commissioner at Lansing, is approximately 450.29 square miles. Of this amount 86.11 square miles is east of Saginaw river; 3.96 square miles is occupied by the river and the Middle Ground. The balance amounting to 360.22 square miles is west of Saginaw bay and the Saginaw river. The area and location as determined from the same Linear Survey sheets, of the different important civil divisions given in the Bay county atlas published in 1896, is as follows:

Bangor, T's 14, 15 N., R. 5 E.....	13.3685	square	miles.
Bay City, T's 13, 14 N., R. 5 E.....	4.885	"	"
Beaver T. 15 N., R. 3 E.....	35.325	"	"
Essexville T. 14 N., R. 5 E.....	1.40	"	"
Frankenlust T. 13 N., R's 4, 5 E.....	23.1625	"	"
Fraser T. 16 N., R's 4 5 E.....	33.2935	"	"
Garfield T. 16 N., R. 3 E.....	35.225	"	"
Gibson T. 18 N., R. 3 E.....	35.5325	"	"
Hampton T. 14 N., R's 5, 6 E.....	27.5119	"	"
Kawkawlin T. 15 N., R. 4 E.....	34.045	"	"
Merritt T. 13 N., R. 6 E.....	32.1275	"	"
Monitor T. 14 N., R's 4, 5 E.....	37.2265	"	"
Mt. Forest T. 17 N., R. 3 E.....	36.2450	"	"
Pinconning T. 17 N., R's 4, 5 E.....	37.3365	"	"
Portsmouth T. 13, 14 N., R's 5, 6 E....	20.1875	"	"
West Bay City T. 14 N., R. 5. E.....	3.945	"	"
Williams T. 14 N., R. 3 E.....	35.515	"	"

3. *Railroads.*

The Michigan Central railroad system ramifies in several different directions from Bay City. The Detroit and Bay City branch running in a southeasterly direction through Munger enters Saginaw county near the south eastern corner of Bay county. The Saginaw division, continued northward from Bay City as the Mackinaw division, unites to form the Jackson, Lansing and Saginaw branch, which runs along the west side of Saginaw river and Saginaw bay, crossing the Saginaw river at Bay City and the Kawkawlin river at Kawkawlin village. From this branch in the northern part of Bay county, the Saginaw Bay and Northwestern branch runs west-northwest from Pinconning through the village of Mt. Forest and thence on to Gladwin. At Mt. Forest the late Mr. Charles Van Lieuw and John Bloomshield of West Bay City, ran the transit line and levels for a spur north through Bently and into Arenac county, which is still quite largely used for lumbering purposes. The Midland division of the Michigan Central runs west after leaving West Bay City, through the village of Auburn, tapping with its spurs several important coal deposits. The Grand Trunk (C. S. & M.) and Pere Marquette systems connect Bay and West Bay Cities with Saginaw, following the Saginaw river. The Detroit and Mackinac railroad parallels the Michigan Central from Bay City to Pinconning. Mr. Henry C. Thompson, City Engineer of West Bay City, ran during the summer of 1902, the levels for the Huron and Western railroad, which follows the quarter line of sections 7-12, T. 14 N., R. 4 E., and thence due east, as originally laid out, to the Saginaw river.

During the lumbering period several spurs were laid out in the northern part of the county, but have been in part abandoned with the decline in the lumber industry. Such an abandoned line, which has been pressed into service for a wagon road, runs through the north half of section 5, Gibson township, entering Gladwin county at or near the west quarter post of section 6, T. 18 N., R. 3 E., a branch running south to about the center of section 7 and connecting with the main line. Another abandoned spur known as the old Nine Mile branch runs through sections 10 and 3 of Mt. Forest township, thence through the southeastern and eastern part of Gibson township, into a part of the county otherwise largely unopened. The Fisher branch, still in use, runs from Mt. Forest village through sections 9, 16, 21, 22, 27, 26, 35 in T. 17 N., R. 3 E. The Eddy branch, which unites with the spur at Fisher Junction in the northern part of section 21, is at present used for a wagon road. This branch runs in a general southerly direction through sections 21, 28 to the southeast corner of section 33, and thence for a short distance into Garfield township. The Sullivan branch, also in use, terminates in section 19 of Mt. Forest township, joining the main Fisher branch in the lower half of section 16. Forming a junction with the Saginaw Bay and Northwestern road, a short abandoned branch runs north approximately along the quarter line of sections 11 and 14, T. 17 N., R. 3 E. Another abandoned line which is partly corduroyed, runs east and west through sections 7 and 8, Mt. Forest township, and was used as a base in running beach meanders. Still another branch started at Pinconning, terminating at Glencoe in the southwestern corner of Mt. Forest township.

Taking the county as a unit; with its situation on the shore of Saginaw Bay and at the head of deep water navigation; with abundant railroad facilities; a progressive and quite complete system of stone roads in the eastern and southern part of the county; the natural resources and geographic location are destined to place the same in the very front rank.

4. *Linear Survey.*

The Linear Survey of Michigan was begun in 1815, and entered Bay county in 1820, when Joseph Wampler ran the township lines of T. 14 N., R. 4 E. Subsequent township lines by the same surveyor were as follows: T's 13 and 14 N., R. 6 E., 1821; T's 13 and 14 N., R. 5 E., east of river, 1822; T. 16 N., R's 4 and 5 E., 1822; T. 17 N., R. 5 E., 1822; T. 15 N., R. 4 E., outside of the reserve, 1822, the reserve being surveyed by John Millett in 1840. Wampler also ran the east line of T. 16 N., R. 3 E., in 1822, the north, south and west lines being run by Robert Clark in 1831. Mr. Clark also ran in the same year the south line of T. 18 N., R. 3 E., the north, east, and west lines being run by Levis Cassen in 1837. Mr. John Millett was employed in running township and section lines to wit: T. 13 N., R. 4 E., 1839; T's 13 and 14 N., R. 5 E., west of river, 1839; T. 15 N., R. 5 E., 1839. Harvey Parke determined the township lines of T's 14 and 15 N., R. 3 E., which completed the township and a portion of the sectional surveys.

Orange Risdon in 1834 ran the section lines of T's 13 and 14 N., R. 6 E. In 1840 John Millett made the sectional survey of T. 14 N., R. 4 E.; in 1846 of T. 16 N., R. 3 E. John Bent ran the section lines of T. 15 N., R. 4 E., outside of the reserve, in 1843, and also those of T. 16 N., R's 4 and 5 E. John Burt ran the section lines of T. 17 N., R's 4 and 5 E., in 1843. Three years later John Millett made the sectional surveys of T's 17 and 18 N., R. 3 E., which completed the Linear Survey within the limits of Bay county.

5. *Maps and Surveys.*

With the exception of the U. S. Lake Survey, of which further mention will be made, all the maps relating to this county are based with a greater or less degree of accuracy upon the Government Linear Survey, which is only approximately accurate for each township unit. The main map of Bay county in this report is largely based on this original survey, together with the chart of the Lake Survey showing the lower reaches of the Saginaw river and considerable of the adjacent shore line of the bay. This information has been supplemented by information obtained from drain surveys relative to intermittent streams and in the field.

"The geological maps of Bay county are those incorporated in some general map like those issued by Winchell in Walling's atlas in 1873, and by Rominger and Lane in Volume III, respectively V of these series of reports." [1]

An earlier map by Winchell, colored to represent the different geological formations in the lower and upper peninsulas, appeared in 1865. In the report on "Water Resources of the Lower Peninsula of Michigan" forming Water Supply and Irrigation Paper No. 30 of the U. S. Geological Survey, is a map revised by A. C. Lane, from a map in Volume V of the state reports. In the annual report of the State Geologist for 1901, is a map based on Silas Farmer's map, and reduced to a scale of one inch to each 56 miles. This shows the section lines and is the most accurate map to date.

Farmer's sectional map published in 1856 in 6 sheets, 7½ miles to the inch, summarizes the result of the Linear Survey, and is a most excellent map. This was issued and revised in various scales and at various dates. Mr. Farmer also published in 1901 an excellent map of the entire state on a scale of 12 miles to one inch. In 1897 the Rand McNally Company published a sectional map of Michigan on a scale of 8 miles to the inch. This map has

[1] Volume VII, Part 2, page 7.

occasionally been used in field and office work by the State Geological Survey. In 1860 the U. S. Lake Survey carefully surveyed the shores of Saginaw Bay. The map which was published in 1860 gives the results on a scale of 1 : 120,000. Another chart gives the Lower Reaches of the Saginaw river and the bar in front: scale one mile to 6.25 inches. The Geological Survey has been permitted to use photographs of the field sheets which were on a scale of 1 : 16,000.

In 1860 a map was issued entitled, "Map of Saginaw and Tuscola with part of Genesee, Lapeer, Huron and Midland counties." In Bay county are the townships of T. 16 N., R. 4 E., T. 15 N., R's 3 and 4 E., T's 13 and 14 N., R's 3, 4, 5, and 6 E., scale one mile equals .65 inch. Published by D. A Pettibone, Surveyor, Bridgeport Center, Michigan. Lithographed, printed and mounted by J. H. Colton & Co., New York.

In 1869 appeared a map of Bay county by B. F. Bush; Fred H. Herbert, Lithographer, East Saginaw. Everything within the limits of T's 13-20 N., R's 2-6 E., was included on this map. East of the river were the townships of Hampton and Portsmouth. Bangor, Monitor and Williams had much the same limits as now; Beaver included T's 15-20 N., R. 3 E.; Kawkawlin T's 15, 16 N., R's 4 and 5 E.; the rest of the county is within the limits of Arenac township. The swamp areas as given on the Linear Survey maps are indicated. The railroad, canal, swamp, and German Seminary lands are indexed by letters. The roads, plank roads and railroads are also distinguished. Scale one mile to the inch.

1873. Walling's atlas of the State of Michigan, already mentioned, contains a separate map of Bay and what is now Arenac county. Within the present limits of the county there are represented 10 civil township organizations, one of which extended into what is now Arenac county. It is rather inaccurate.

1875. Wm. Mercer, for many years City Engineer of Bay City, published a map of Bay City and the villages of Wenona (West Bay City), Banks, Salzburg, Essex and vicinity. This was compiled and drawn by Mr. Mercer. Scale one mile to every 13 inches.

In 1883 H. R. Page and Co., of Chicago published a history of the Lake Huron Shore containing biographical and other matter with a map of Bay and Arenac counties.

1884. Map of the Saginaw river and the cities of the Saginaw Valley, published by the Saginaw Board of Trade, accompanying the report for 1884. Scale 4,000 feet to the inch. The location of the different firms represented in the saw mill, shingle mill, salt works, solar field and planing mill business are given.

1885. Another map of Bay City by Geo. Turner, Surveyor and City Engineer, 1885. Scale 400 feet to one inch. Drawn by F. Tittman, C. E., 1895. Mr. Turner published another map of the city on a scale of 800 feet to one inch.

1886. Mr. Henry C. Thompson published a map of Bay county on a scale of 2 inches to the mile, based on the Linear Survey. Certain portions of the map giving accurate road meanders were used on the Geological Survey map. Mr. Thompson has also an excellent map of West Bay City.

1894. In this year appeared another map of Bay county by Henry C. Thompson, West Bay City. The scale is 2 miles to the inch. School districts are designated by large figures and their boundaries by dotted lines. This is the original of the Bay county land map extensively used by F. J. Tromble of Bay City.

1896. An atlas of Bay county was published by D. A. Bullock & Co., of Bay City, with a general map of the state and county; with township and outline maps of Bay and West Bay Cities on a scale of 2.5 inches to one mile, the cities being represented in greater detail on other sheets; village plats are on a scale of 13 inches to the mile. The township maps were largely constructed from deeds in the county records. Blue prints made from these maps were used by the Geological Survey in the field.

1902. This map was published by Snyder and McCabe of the Bay City "Tribune." Scale one and one-half inches to the mile. The roads, stone roads, railroads, electric lines, rural postal routes, are each designated. The most recent property owners are given, with the location of the houses, churches, school houses, and coal mines at that time in operation. The population of the Bay Cities and townships in 1900 is also tabulated.

1905. Soil survey of the Saginaw Area, Mich., by W. E. McLendon and M. Earl Carr, U. S. Dept. of Agriculture, 1904. This embraces all the area of Bay county as far north as the south line of Garfield and Fraser townships.

In this connection I desire to acknowledge my indebtedness to Mr. John H. Blomshield of West Bay City for a meander of the mouth of the Saginaw river made in February, 1894, with the location of the original meander lines. The scale is three chains to one inch. Mr. J. F. Pratt, Engineer of the Michigan Central R. R., stationed at Bay City has also given the Survey valuable information relative to lumber and other railroad locations in Mt. Forest township, which we have incorporated on the map in this report.

6. *Historical.*

Originally occupied by the Sacs and Fox, as far as our present knowledge goes, these tribes were displaced by the Chippewa or Ojibway Indians from the north, after being almost exterminated. Mr. W. T. Shaw, who was employed by the Survey in the northern part of the county, writes that the Indians had a tradition of the time when Saginaw Bay extended to the Algonquin shore line now traversed by the East Saginaw and Au Sable State Road. If this tradition did not occur to the Indians from the analogy of the old and present beach lines, it implies an antiquity of some 2,000 years. The finding of stone implements in the till of southern Ohio would point to such a possibility. Mr. Harlan I. Smith of the American Museum of Natural History, has recently been engaged in investigations for that institution.[3] He finds that the Chippewas living in the valley today, have much the same culture, and are manufacturing many of the same implements as he excavated from the mounds near which they are living, and he concludes, are therefore the descendants of the mound builders. The mounds appear to be mostly filled with the remains of the unfortunate Sacs, who were massacred at the time of the invasion. With the advent of the early French traders, the civilization of the whites replaced in part, the culture of the red, so that we have the dignity of the "plug" instead of the coonskin, clay-pipes instead of the ornamental stone, while to make the evolution complete, there is the black bottle filled with fire water.

In the beginnings of settlement geography, and its precursor geology, go hand in hand with history, the divergence becoming wider and wider as culture advances, and the art of man enables him to assume the mastery over nature.

Originally a part of Saginaw, Midland and the whole of Arenac counties,

[3] Harper's Weekly, Jan. 3, 1903.

this territory was organized into Bay county in 1857. The townships of Hampton and Williams had been heretofore organized in 1843 and 1853, being the only townships with a full organization. At a special meeting of the Board of County Supervisors in February, 1859, the territory of Arenac was separated into a township. In March, 1859, the township of Portsmouth was organized, while later in the same year, the township of Bangor was separated. The State Legislature in 1867 separated Beaver township from Williams which lies to the south. The Board of Supervisors in January, 1868, passed an act organizing the township of Kawkawlin which had previously formed a part of Bangor. In 1869, Monitor township was established by the legislature. Two years later in 1871, the old township of Portsmouth was divided and the township of Merritt constituted. In 1873 the township of Pinconning was organized by the State Legislature. In 1875 Fraser township was formed, with Wm. Mitchie as its first Supervisor. The township of Frankenlust was detached from Saginaw county, and annexed to Bay in the winter of 1880. Mr. W. V. Renner, Township Clerk of Garfield, writes as follows: "Prior to April 4, 1897, Garfield was a part of Fraser township. At the annual October session of the Board of Supervisors in 1896, said board ordered that T. 16 N., R. 3 E., should be organized and known as Garfield township. I have been informed that the township of Gibson, which previously formed a part of Pinconning, was separated in 1889." During the biennial session of the legislature in 1902-1903, the township of Gibson was annexed to Arenac county, but this act was declared unconstitutional by the Supreme Court. Mr. Thomas Cronk, Township Clerk of Mt. Forest, writes that the township was set off in 1890, forming previously a part of Pinconning township.

In 1851 appeared a pamphlet by Frederick C. L. Koch entitled "Die Deutschen Colonien in der Nahe des Saginaw-Flusses." This is accompanied by a map showing the location of the colonies in Frankenlust and Amelith.

7. *Previous Geological Work.*

There being no outcrop of rock in Bay county, it received but little attention from the first Geological survey. However, Douglass Houghton, the first State Geologist, in his second annual report submitted in February, 1839, remarks:

"The country north of the southern boundary of Arenac county" (at that time part of Bay county) "and east of the Meridian, so far as examined, is on the whole but ill adapted to the purpose of agriculture, being chiefly composed of sandy ridges with intervening swales, and rising so gradually toward the central portions of the state as to leave the country extremely flat. There are, however, many valuable tracts of white pine, which will serve to render this portion of the state of some importance. Yellow pine well adapted for light spars also abounds."

A large portion of the immediate shores of the lake is composed of marsh."

As will be seen, the author was under considerable misapprehension concerning the agricultural resources of the region, but his description of the topography sufficed to give an idea at that time.

In his fourth annual report, published in 1841, page 132, the Pleistocene deposits are termed Tertiary clays. They are stated to have a thickness of from 1 to 100 feet.

In the first biennial report of Alexander Winchell published in 1860, coal *is stated to* underlie the greater part of Bay county.

Dr. Carl Rominger in Volume III, page 69, gives some details of two salt wells at Kawkawlin of which further mention will be made. There is also given in the same report, in the Appendix by Dr. S. S. Garrigues, a list of the companies engaged in the salt industry in this county.

In 1873 A. Winchell prepared for Walling's Atlas a number of articles which were reprinted under the title, "Michigan, Being Condensed, Popular Sketches of the Topography, Climate and Geology of the State." [3]

In Bulletin 99 of the Michigan Agricultural Experiment Station, 1893, is a soil analysis from the farm of Judge Marston, Bay City, but which I believe is from the Algonquin beach near Kawkawlin, northwest of West Bay City.

For the following reference I am indebted to Mr. Lane, who has translated the work mentioned. "The earliest extensive treatment of the salt manufacture in the Saginaw Valley was by Dr. H. C. Hahn, in the 'Berg und Huettenmaennische Zeitung' for 1869, in a series of articles running through the year from page 97 to page 339. Dr. Hahn was located in the New York and Saginaw works in Saginaw county, and it is intended to give a full account of his tests in the Saginaw county report. He published, however, some analyses from the Portsmouth Co., the Bangor Co., and Gilmore (well) in Bay City which were made by Dr. Goessmann and are given in a paper on salt manufacture which Garrigues published in Volume III of our reports." In Volume V part 2, of the same series of reports, there are numerous references concerning the stratigraphical geology of Bay county, to which reference will be made in their proper place in Chapter II. Also in Volume VII, part 2, Lane has compared the stratigraphic succession in the two counties of Huron and Bay.

Volume VIII of the series of State quarto reports is devoted to the economic geology of the lower peninsula of Michigan. Part 1 of this volume is by Dr. H. Ries, being a report on the clays and shales of Michigan. Part II, by A. C. Lane, is the final report on coal, the preliminary report appearing serially in the "Michigan Miner," Volume I, Nos. 3-10, February to September, 1899. Further reference will be made to this volume in the chapter devoted to economic geology and the coa measures.

Mr. F. B. Taylor has been engaged in tracing the Algonquin and Nipissing beaches from the west side of Saginaw bay to the Straits of Mackinac. [4]

In 1897 appeared an article by Taylor in a Bulletin of the "Geological Society of America," Volume 8, pp. 31-58, with a plate showing the location of the moraine on the east side of the Tittabawassee river.

In the annual reports of the State Geologist, A. C. Lane, for 1901 and 1902, are incidental references to the geology of Bay county, to which reference will be made further on. Mr. Lane has written for the series of Water Supply and Irrigation Papers of the U. S. Geological Survey, Bulletin No. 30, on the "Water Resources of the Lower Peninsula of Michigan," in which are found references to the Pleistocene geology quite applicable to the Saginaw bay basin.

Finally in the different numbers of the "Michigan Miner" edited by the late Mr. C. B. Schaefer, there have appeared articles from time to time, bearing on the geology and physical geography of this county. This monthly was later edited by Messrs. Davis and Clark, and at the present time is edited by John W. Clark.

[3] Volume VII, Part 2, page 4.
[4] American Geologist, Volume XVII, pp. 253–257, 1896.

8. *Recent Work.*

The detailed field work in Bay county was undertaken in the summer of 1900 by Prof. W. T. Shaw, who was at that time connected with the Michigan Agricultural College, and myself. The upper part of the county comprising the townships of Kawkawlin, Fraser, Garfield, Pinconning, Mt. Forest, and Gibson, were worked by Mr. Shaw, while I finished the field work in the northern part of Saginaw county and the remainder of Bay. This field work consisted for the most part, of collections of well records, and data from which a soil map could be prepared. In the fall of 1900, with headquarters in West Bay City, about three months were spent in obtaining maps, locations and levels of the various drains which had been dug in the county, along with a good many incomplete lines. Specific acknowledgement and suggestions in connection with the subject will be found in connection with the chapter on Physical Geography and Drainage.

In the summer of 1901, Mr. John H. Blomshield and I were engaged in running 33 miles of levels in order to obtain the elevation of certain inland drains and records, as well as to furnish base lines for aneroid elevations in the western and northwestern part of the county. From this work it is possible to obtain an accurate idea of the elevation of each drain line above the Bay, or as it is expressed, above tide, the elevation of the bay being 580.37 feet A. T. during August, 1902.

In the fall of 1901 I spent three weeks in getting aneroid elevations west of the Saginaw river. In the fall of 1902 this work was completed for the entire county, obtaining sufficient data for a five foot contour map of that area.

Outside of the stream valleys and beach lines showing former lake margins, the topography of Bay county is comparatively even. In the spring and fall of 1902, meanders were run over all beach lines of any importance. This greatly facilitated the work of contouring, beside adding to our knowledge of the Pleistocene lake history.

During the summer of 1902 Mr. Floyd D. Owen of the Michigan Agricultural College was engaged in studying Bay county waters. The results of his work appeared in the annual report of the State Geologist for 1902, under the title, "Some Field and Laboratory Tests of Bay County Waters." Further mention will be made of this in some notes on the water supply of the county.

Mr. Geo. M. Bradford of Bay City has prepared a very complete paper on the flora of the county showing the different plant societies, ecology, and lists of species. His father, P. A. Bradford, is also actively engaged in the same subject, and I am indebted to him for suggestions about submerged shore lines.

Finally while engaged in obtaining levels in Bay and West Bay Cities, I obtained the records of 361 test holes for coal of which further detailed mention will be made where they belong, but principally in Chapter III on Coal. Subsequently 101 additional records have been obtained.

CHAPTER II.

GEOLOGICAL COLUMN.

1. *Introduction.*

By a geological column is meant a section down into the earth's crust, showing the various materials of which it is composed in that particular district. In the section here given the greater part of our information was obtained from the record of the deep well at the North American Chemical Company at South Bay City. We have also introduced other records from the Lower Peninsula for comparison whenever possible.

2. *Pleistocene, the Drift, Soils and Sub-soils.*

Our first division includes the materials most recently laid down, or even now in the process of formation. This includes for the most part beds of muck, alluvial deposits, and small accumulations of bog iron ore. By referring to the soil map, it will be observed that in a portion of the region west of the Algonquin shore line in Kawkawlin township, there is a considerable area of muck land, which at the time of the Linear Survey was occupied by a swamp. This has now been drained forming fertile land. The soil is largely the result of the decay and accumulation of vegetable remains. Beds similar in origin are also met with in the territory adjacent to the State drain in Merritt township, in the southwestern portion of Williams township, and the southwest part of Mt. Forest, besides numerous areas of lesser extent. Such beds are also now in process of formation in the low lying tracts adjacent to Saginaw bay in the southern part of Bay county, and around Tobico Bay in Kawkawlin township. The present conditions under which these beds are accumulating afford a satisfactory explanation of the somewhat earlier deposits mentioned above. Carrying the parallel farther back into time, the coal beds which underlie Bay county are formed of spores and vegetable deposits, which very probably accumulated in estuaries and inlets of the Carboniferous sea. Muck, however, may be said to be the first stage in the formation of coal.

Beds of alluvium are formed where the transporting power of water is insufficient to hold the material in suspension. In Bay county during times of freshet, such accumulations are formed in Saginaw Bay near the mouth of the river. In periods of low water, or when northeasterly winds prevail, the river being practically an estuary of the Bay, would drop its deposit farther up stream. The bar situated between Bay City and Saginaw may represent such a deposit. More rarely flood plains are formed in lateral deposits along the bank of streams, forming a dam which prevents direct drainage into the river. Such a deposit was probably formed at the time when the Lower Fork of the Kawkawlin river emptied into lake Algonquin. This may be seen on the south bank of the stream, just east of the line between Williams and Monitor townships.

Deposits of bog iron ore with a considerable amount of siliceous mate-

rial are occasionally found in the sand ridges back from the bay. The iron has probably been leached out of the sand by organic acids, leaving an almost perfectly white sandy deposit above.

Adjacent to the bay are ridges of sand which are the result of the action of wind and water. The transporting power of the wind in carrying particles of sand may be readily observed on any stormy day. At a somewhat earlier period delta deposits of sand accumulated on the shore line of the Pleistocene lakes. A typical deposit of sand of this character may be seen about one mile south of the home of Pierre Lemieux in the eastern part of Kawkawlin township. Delta deposits which in the aggregate seriously impede the effects of drainage may be observed in numerous places, where small rivulets carry their burden of sediment into drain courses. Moreover, the main drainage lines themselves deposit considerable amounts of sediment along their flood-plains, or form delta deposits in streams tributary to Saginaw Bay.

The deposits described above have obtained their material for the most part from the beds of unconsolidated drift formed at a time when the physical geography was somewhat different from the present. These beds of clay, hardpan, sand and gravel vary in thickness from 30 feet in the northeast part of Fraser township to 220 feet at Auburn, even having a greater development farther west near the Midland county line. An average depth of these Pleistocene deposits, determined from the records of 462 test holes for coal and 126 well records scattered over Bay county, would make the thickness 97 feet. Where the surface deposits are clay, generally underlain by hardpan forming the Wisconsin drift sheet, the average of 406 test hole records for coal make the upper drift formation 82 feet. This is underlain at greater depths, by strata of sand and gravel, occasionally inter-stratified with beds of clay, being of pre-Wisconsin age, and having an average thickness of 33 feet. The coal hole records being from the lower third portion of Bay county, it is impossible to give an estimate for the two divisions of the drift for the remaining portion of this region.

Beds of interglacial material have occasionally been found in the construction of shaft holes. Near Amelith, in the shaft of the Pittsburg Coal Co. such a deposit was met with at a depth of 110 feet, being underlain by beds of sand and gravel and overlaid with clay drift of Wisconsin age. At the shaft of the old Monitor mine, similar deposits of later age, probably forming a subdivision in the Wisconsin drift sheet, were obtained at a depth of 45 feet. In the shaft hole of the Hecla mine, in the northeastern part of Frankenlust township, fragments of trees were found in beds of sand just above the bed rock, at a depth of 85 feet. This vegetal deposit is probably contemporaneous in age with the 110 foot bed near Amelith. For additional information concerning these deposits, the reader is referred to Chapter IV on soils and sub-soils.

3. *Coal-bearing Measures or Saginaw Formation.*

Within the limits of Bay county, the coal formation consists for the most part of strata of sandstone, shale and coal of variable quality and thickness. Carbonates of iron and lime occur in nodules or thin beds. Iron pyrites is also occasionally found with the coal or shale. The formation varies in thickness, owing both to glacial and preglacial erosion, and to the elevation of the basement on which the coal formation rests. Thus the coal measures *in South Bay* City have a thickness of 350 feet, the base of the formation

being 90 feet above tide (A. T.). At Bradley's deep well on the Bay-Tuscola county line, the top of the Parma comes in at a depth of 367 feet, or 216 feet above sea level, showing how the lower series, on which the coal formation rests, rises in that direction. West of South Bay City, in the center of section 4, T. 13 N., R. 4 E., a hole put down by W. L. Ralston enters the Parma sandrock at a depth of 409 feet, or very nearly 200 feet A. T. The drift here is 108 feet in depth, which makes the coal formation 300 feet thick. This hole is probably near the top of an anticline running north from Saginaw. Farther west at Midland, the Pleistocene or drift is 285 feet thick, and the coal measures 525 feet. The underlying Parma also shows an increased thickness. Towards Saginaw the coal measures show a considerably decreased thickness, which is also true of the formation northward from Bay City. In Arenac county the underlying Grand Rapids formation comes to the surface in the northeastern part of the county.

Within this formation from 10 to 12 beds of coal have been deposited at different elevations. A detailed account of these strata and the associated beds is given in the following chapter.

4. *Parma Sandstone.*

This bed immediately underlies the coal measures. At the South Bay City well, it is a light colored sandstone overlain by a bed five feet thick, chiefly composed of iron pyrites. The same relationship is observed at Bradley's well where the sandrock is apparently 107 feet in thickness. As has already been observed, the Parma increases considerably in elevation in this direction. At Midland the Parma is a white sandstone 110 feet thick. I am not aware that this formation has been identified in Arenac county. In the well drilled by Ralston in section 4 of Frankenlust township, the thickness of this formation was not determined.

5. *Upper Grand Rapids.—Maxville or Bayport.*

For a detailed account relative to the age of this formation, the reader is referred to the report on Huron county by Lane.[5] The order of sequence of these beds is not unlike that given for the "Thumb." In the samples from the deep well at South Bay City, beds of brown siliceous dolomites extend down from 540 to 560 feet. These in turn are underlain by even grained, green, apparently homogeneous siliceous beds of dolomite for a depth of 50 feet. This is underlain by light colored beds of sandstone and shale for 10 feet, with dark shaly rock mixed in. The entire thickness as thus given is approximately 70 feet. In Huron county where these beds are well exposed around Bayport, Lane makes the maximum thickness 50 feet. Northwestward in Arenac county the formation is quarried northeast of Omer at Griffin's quarry. These beds are apparently not represented in the well records at Midland or Saginaw.

6. *Lower Grand Rapids.*

This is the Michigan Salt Group of A. Winchell and the Michigan Series of Lane in his report on the geology of Huron county, to which the reader is referred for information regarding the age of these deposits, which are there correlated with the Augusta, or Burlington and Keokuk limestones of the Mississippian series. The entire series represents rapid alternations of dolo-

[5] Volume VII, Part 2, p. 12.

mite, limestone, shale and gypsum, indicating constant changes in physical conditions. In the samples obtained from the South Bay City well, the sequence beginning at the top, is as follows:

From 620 to 625 feet, drab colored dolomite with fragments of shale and chert, underlai[illegible] by 25 feet of gray shale down to 650 feet. In the drillers log which was [illegible] the annual rep[illegible] The sample, h[illegible] next 30 feet d[illegible] stone. The d[illegible] coming lighter [illegible] down to 720 [illegible] stone, and 10 [illegible] the column, s[illegible] gray colored s[illegible] indicated as [illegible] shales down [illegible] 740 to 750 f[illegible] which is succ[illegible] In the log an[illegible] limestone, fro[illegible] feet of limest[illegible] of the format[illegible] rites, down t[illegible] a gray shaly [illegible] of the Lower [illegible] county Lane [illegible] strata have [illegible] less alternat[illegible] we have see[illegible] At Midland [illegible] ing a depth [illegible] land Chemic[illegible] ward appro[illegible] the base of [illegible] City well.

This form[illegible] lent beds i[illegible] stone, cont[illegible] salt horizo[illegible] shaly, bec[illegible] formation i[illegible] ation in structure, in the [illegible] thickness is very nearly 150 feet, or half the depth of this formation [illegible] county. The line between this and the underlying formation is arbitrarily drawn. I am inclined to believe that the beds of red sandstone aggregating 100 feet in thickness, should be included with this, rather than the lower Marshall.

8. *The Lower Marshall.*

In its entirety, this portion of the column is composed of blue and reddish beds of sandstone and shale extending in depth from 970 to 1290 feet, in the South Bay City well. The order of sequence beginning at the top is as follows:

From 970 to 1,070 feet red sandstone.
From 1,070 to 1,100 feet blue shale.
From 1,100 to 1,120 feet red shale.
From 1,120 to 1,140 feet red sandstone.
From 1,140 to 1, 185 feet blue shale.
From 1,185 to 1,190 feet red shale.
From 1,190 to 1,290 feet red sandstone.

The entire thickness of the formation as thus determined is 320 feet. In Huron county Mr. Lane makes the thickness of the more or less equivalent beds 265 feet. Both here and in Huron county this formation is a transition from the heavy beds of shale composing the underlying Coldwater series, to the solid Napoleon sandstone formation just described.

9. *Brines of the Marshall Sandstone.*

In the salt wells put down in Bay City, and in the adjacent region to the north and south, the depth to brine is seen to vary considerably, the bottom of the syncline or trough being not far from Hargraves Mill on the Middle Ground, where the depth is 1,040 feet. Northward from here at Pitts and Craniges, near the Michigan Central R. R. bridge, the depth to the top of the brine is about 1,000 feet; at the Detroit and Mackinaw bridge 920 feet; at Boyce's in Essexville 800 feet; near Kawkawlin from 700 to 800 feet. Going south from Hargraves Mill the depth to brine is also seen to increase in elevation. Thus at the plant of the North American Chemical Co. at South Bay City, brines are struck at 850 and 890 feet in depth, the salt water sandstone extending down to 970 feet; at Melbourne one-half way between Bay City and Saginaw at 890 feet deep; at Zilwaukee 810 to 840 feet. Southward from here the salt brines are found at a minimum depth of 710 feet at Wylie Bros.' well in Saginaw, increasing in depth towards Garfield and St. Charles.

10. *Coldwater Shale.*

In the South Bay City well there is included within this part of the geological column, a series of reddish, light, and dark blue shale beds having a depth of from 1,290 to 2,060 feet. The series as represented in the drillings is essentially a shale deposit, characteristically blue in color. The beds are quite uniform lithologically, as far as the drillings show. From the top of the formation down to 1,750 feet are light blue shales becoming darker at 1,800 feet, and again light blue for 100 feet more or less, down to a depth of 1,900 feet. At 1,920 feet red shales, with a light blue shale at 1,940 feet, becoming a dark reddish sandy shale at a depth of 1,950 feet. At 1,960 there are blue shales again for 100 feet, forming the base of the series. The drillings do not tally with the account kept in the drillers log.[8]

The thickness of the formation as given above is 770 feet. In the Huron county section described by Mr. Lane, the thickness of the formation, including the transition beds merging into the overlying Marshall, is 896 feet.

[8] Annual report of the Michigan Geological Survey for 1901, page 224.

MICHIGAN SURVEY

In the deep well put down for rock salt at South Bay City, this formation is a characteristic gray or white sandstone having a thickness of 130 feet. The bottom of the formation is reached at a depth of 2,290 feet. In the drillings the beds at 2,115 feet are light gray colored sand rock, "very hard," and fine grained with fairly strong brine. Thence down to 2,140 feet, the beds become darker with black shaly partings. At a depth of 2,150 feet the water in the drill hole was within 100 feet of the top, which flowed over the surface at 2,170 feet. The flow amounted to 1.25 gallons in 3.5 minutes. From 2,180 to 2,260 feet, fine hard white sandstone of uniform texture. At 2,230 feet, the well overflowed 19.19 gallons per hour. At a depth of 2,265 feet beds of sandstone and blue shale, which grade off into the underlying formation at 2,270 feet. In the salt well put down at the Atlantic Mill in the northern part of Bay City, this formation is represented as having a thickness of 165 feet.[9] The increased thickness of 35 feet, when compared with the record at South Bay City, is probably due to additions to the base of the formation, as the bottom of the grit here is at a depth of 2,306 feet as against 2,270 feet in the former well. The elevation of the two well heads is very nearly the same.

In Huron county the Berea Grit is 70 feet thick. At Alma the Berea is not represented.

13. *Antrim Shales.*

In the geological column this is nearly the same as what is known as the Ohio black shale in that state, where the latter formation includes, beginning at the top, the Cleveland, Erie and Huron shales. The Antrim also includes the Bedford shales. The name Erie being preoccupied, this formation has been recently designated the Chagrin formation by Prof. C. S. Prosser of the Ohio Geological Survey. The Chagrin shale is characteristically blue, and is nearly, if not quite, the equivalent of the Chemung formation in northern Ohio. The black shale formation has a widespread geographical distribution, extending as far south as Blount Springs, Alabama, and northward into Cheboygan county of this state. It was formerly designated the St. Clair shales by Mr. Lane, but the name was found to be preoccupied.

In the drillings from the well of the North American Chemical Co. at South Bay City, the top of this series is a blue shale extending from 2,270 to 2,290 feet in depth. This was provisionally included with the Bedford shales, but I am now inclined to believe that it is the representative of the Chagrin or Erie or Chemung formation in this state. In Volume V, Plate VI, there is indicated as Erie a white shale formation in the well of the Atlantic Mill, which extends in depth from 2,306 to 2,371 feet. If this correlation is supported by further evidence, it will eliminate the Cleveland shale from the geological column in this portion of Michigan. This leaves the great bulk of this formation as the general equivalent of the Genesee black shale of New York, and the Huron shale of Ohio.

In the South Bay City well, the Antrim shales extend in depth down to 2,610 feet; at Atlantic Mill down to 2,585 feet, having a total thickness of 320 feet at the former locality, and of 279 feet at the latter place. The formation is essentially a black shale occasionally shading off into brown, with signs of oil and gas. At 2,380 and 2,490 feet the formation is somewhat calcareous. This calcareous material may represent the great concre-

[9] Vol. V, Plate VI. There were two wells, one 2,900 feet deep the other 2,250, at this location,—the Hall well, No. 93½ of the Saginaw Board of Trade map. When they struck the Berea Grit, wells near by, the Folsom wells, only down to the Marshall, flowed. There was also one well on the west side of the river down to the Berea Grit,—Maclean's well near 28th Street.

In the deep well at Alma, the beds composing this formation are 675 feet in thickness. At Grayling the Coldwater has apparently a thickness of 965 feet.[7] It will thus be seen that while this formation tends to decrease in thickness west from Huron county, the depth of the deposits increase considerably towards the northwest.

There are numerous outcrops of this formation in Branch and Huron counties, containing in places beautifully preserved fossils in nodular structures.

11. *Berea Shale, Sunbury Shale.*

This formation which has until recently been known as the Berea shale formation, has been recently designated the Sunbury shale in an article on the "Nomenclature of the Ohio Formations."[8] The name Sunbury has the right of priority.

This bed, which is a subdivision of the Coldwater shale, in common with its counterpart in Ohio, nowhere attains a very great thickness, but is notable for its persistency, the outcrop extending north and south from the Ohio river, at least as far north as Saginaw Bay.

In the South Bay City well, this is a black shale showing marked signs of oil and gas. The thickness of the formation here amounts to 40 feet, carrying the section down to a depth of 2,100 feet below the surface. In the section of the deep well printed in Volume V, Plate VI, of the Michigan Geological Survey report, located at the Atlantic Mill in the northern portion of Bay City, this same formation has a thickness of 35 feet. The bottom of the formation there has a depth of 1,833 feet, showing a considerable upward dip of the beds from South Bay City. Whether this upward trend of the formation is part of a local anticline, or merely the general dip forming the great Saginaw Valley syncline, is not determined. The occurrence of very considerable bodies of gas encountered during the drilling of this well, rather leads to the former view. It was observed in the record of the well put down by W. L. Ralston in section 4, T. 13 N., R. 4 E., near Bay No. 2 mine, that there was a strong upward fold or anticline of the coal measures passing underneath that place. Such folds occasionally serve for the accumulation of oil and gas when sufficiently porous, and capped with an impervious covering, which in this case is served by the overlying Coldwater shales. Whether or not the Berea shale conforms to this upward trend of the overlying coal measures is largely a matter of speculation. It would seem, however, from the oil well put down by Mr. Gage near the southwest corner of section 26, Monitor township, T. 14 N., R. 4 E., that this anticline extends down into the Coldwater shale. It would be better to prospect a mile west; say near the old Monitor mine, or one mile south of there.

The Berea shale has not been reached in drilling at Saginaw. At Alma this formation has a thickness of 25 feet, the bottom of the beds being at a depth of 2,300 feet, or 210 feet below the same formation at South Bay City.

12. *Berea Grit.*

This is a famous producer of oil, gas and brine in Ohio. The same remarks that were made concerning the overlying formation in the territory adjacent to Bay No. 2 shaft in Frankenlust township, hold with this formation also.

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[7] Annual report of the Michigan Geological Survey for 1901, page 231.
[8] *Journal of Geology*, Volume XI, No. 6, 1903.

In the deep well put down for rock salt at South Bay City, this formation is a characteristic gray or white sandstone having a thickness of 130 feet. The bottom of the formation is reached at a depth of 2,290 feet. In the drillings the beds at 2,115 feet are light gray colored sand rock, "very hard," and fine grained with fairly strong brine. Thence down to 2,140 feet, the beds become darker with black shaly partings. At a depth of 2,150 feet the water in the drill hole was within 100 feet of the top, which flowed over the surface at 2,170 feet. The flow amounted to 1.25 gallons in 3.5 minutes. From 2,180 to 2,260 feet, fine hard white sandstone of uniform texture. At 2,230 feet, the well overflowed 19.19 gallons per hour. At a depth of 2,265 feet beds of sandstone and blue shale, which grade off into the underlying formation at 2,270 feet. In the salt well put down at the Atlantic Mill in the northern part of Bay City, this formation is represented as having a thickness of 165 feet.[9] The increased thickness of 35 feet, when compared with the record at South Bay City, is probably due to additions to the base of the formation, as the bottom of the grit here is at a depth of 2,306 feet as against 2,270 feet in the former well. The elevation of the two well heads is very nearly the same.

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tions which are occasionally found in the Ohio outcrops. They do not form true bedding planes.

Somewhat anomalous is the reported occurrence of a bed of rock salt toward the top of the formation (from 2,304 to 2,310 feet), having a thickness of 6 feet. May not this really have been precipitated in the bottom of the hole? Apparently this formation, during the latter stages of its deposition at least, was deposited in a more or less enclosed sargassum sea.

In Huron county the Antrim or Ohio shale is represented as having an entire thickness of 463 feet, of which 270 feet is assigned by Mr. Lane to the Huron shale.[1] At Alma these shales extend in depth from 2,360 to 2,750 feet, having a total thickness of 390 feet. At Grayling, the Antrim shales have a thickness of 575 feet down to a depth of 2,165 feet. Specimens of black shale have been found embedded in the drift at Indian River in Cheboygan county, which is three miles further north than represented on the latest geological map of the state.

Altogether this formation is one of the most widespread and well marked of the lithological datum-planes.

14. *Traverse Group, Marcellus Shale.*

At the South Bay City well this formation is broadly divisible into three general divisions, consisting of an upper shaly portion with occasional thin beds of limestone, a central division with siliceous beds of limestone, and a lower division of shale beds capped by sandstone, with a single horizon of limestone. The middle limestone division may correspond to the "middle" limestone described by Mr. Lane in the St. Clair river region.[2] Mr. A W. Grabau in his report on the "Stratigraphy of the Traverse Group of Michigan"[3] also makes out an upper shaly series, a middle limestone division, and a lower portion composed of shales and limestones. This is in the vicinity of Alpena. It would thus seem that the Traverse formation is quite persistent in its stratigraphy in the eastern portion of the Lower Peninsula of Michigan. The details of the record of the South Bay City well, as made out from the drillings, are as follows: From 2,610 to 2,620 dark gray sandy limestone, effervescing freely in acid, with fragments of black shale from the overlying transition beds mixed in. Then dark calcareous sandstone for the next 10 feet, becoming light colored from 2,630 to 2,635. At this depth blue calcareous shale down to 2,690 feet, having a thickness of approximately 55 feet. This is underlain by limestone with fragments of *Aulopora*, *Favosites*, and the omnipresent *Atrypa reticularis*, with a thickness of 10 feet, down to a depth of 2,700 feet. For the next 27 feet the limestone gradually becomes more shaly, passing into a bed of blue calcareous shale, extending from 2,716 to 2,727 feet. This is the bottom of the Upper Traverse division, which is here 117 feet in depth. Grabau is of the opinion that the upper Traverse division is not represented in the Alpena section. Whether this is the equivalent of our portion of the South Bay City section, has not been determined.

Next below there is a bed of salt and pepper limestone, almost identical in appearance with that occurring from 2,690 to 2,700 feet, in which I was unable to find any fossil fragments. This bed carries the series down from 2,727 to 2,734 feet. From 2,734 to 2,740 feet is a briny calcareous sandstone of a light gray color, with indications of gas. This salt brine sand-

[1] Michigan Geological Survey, Vol. VII, Pt. 2, p. 29.
[2] *Volume V*, part 2, p. 24.
[3] *Annual report of the State* Geologist for 1901. p. 169.

stone extends to a depth of 2,760 feet, with but little variation, the strata becoming gradually darker from 2,760 to 2,780 feet. From 2,780 to 2,810 feet is a light sandy limestone effervescing briskly with acid; at 2,810 to 2,860 feet a dark brown sandy limestone. From 2,860 to a depth of 2,905 feet, there is 45 feet of dark gray sandy limestone containing brine. This is underlain from a depth of 2,905 feet to 2,940 feet, by a fine grained, pepper colored siliceous limestone, which is said to contain gypsum in the drillers log. This series of limestone beds capped by sandstone, constitutes the second or middle division of the Traverse formation, as outlined above. The entire thickness is 213 feet.

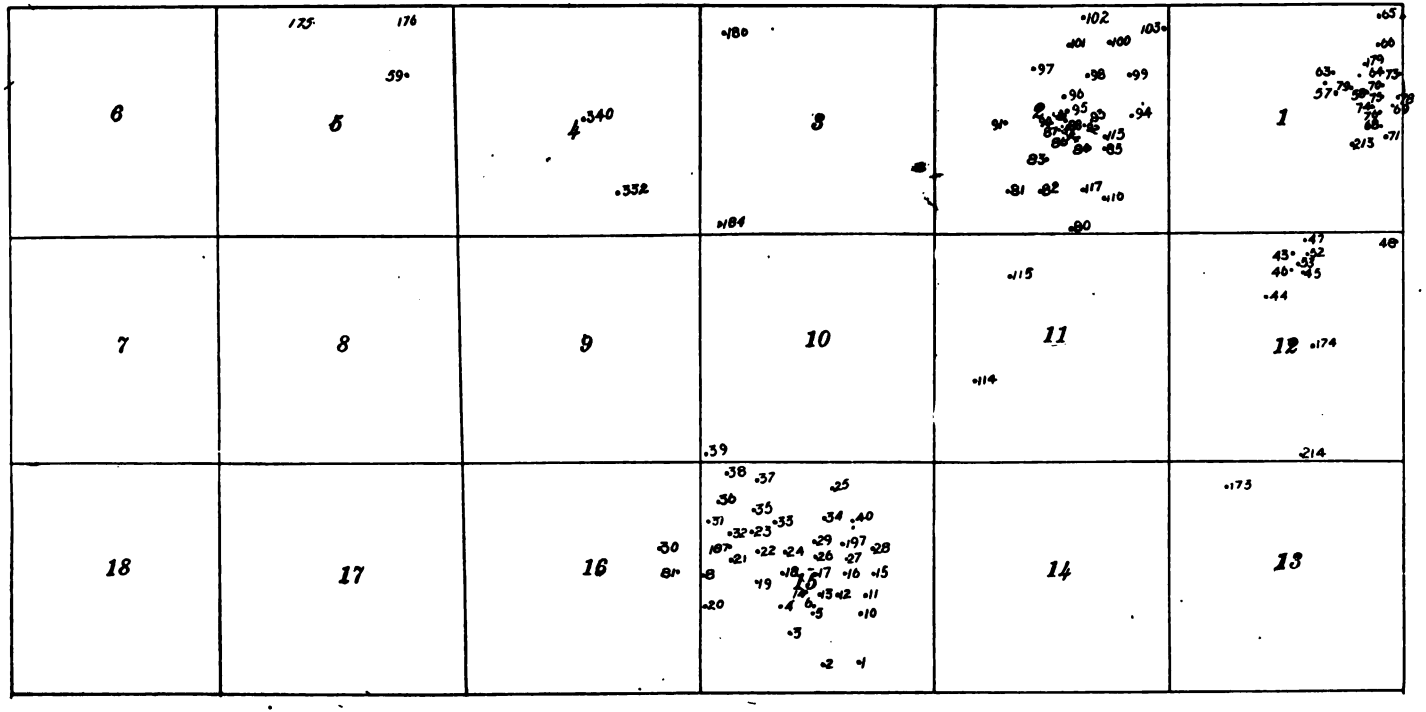
From 2,940 to a depth of 3,120 feet, the Traverse formation is composed of characteristic blue calcareous shales, not unlike the outcrop at Hill's gulch near LeRoy, Genesee county, New York. These shales effervesce freely in acid. This is underlain by 40 feet of fine, steel gray, slightly shaly limestone, down to 3,160 feet. The bottom of this series is a blue shale 50 feet thick down to a depth of 3,210 feet. This would make the thickness of the lower shaly series with its interstratified bed of limestone, 270 feet thick.

The black bituminous Marcellus shale is closely allied faunally with the overlying beds, but on account of its persistency of outcrop and well marked lithological characteristics, it is usually given a definite designation. In the drillings from the South Bay City well, this black shale is stated to have a thickness of 60 feet, or down to a depth of 3,270 feet below the surface. This forms the bottom of the Traverse formation, and is in a sense, a portion of the lower Traverse group.

The entire thickness as outlined above is 660 feet, showing an enormously increased thickness when compared to the same formation in the southeastern part of the state. In the deep wells at Grayling and Killmaster, the bottom of this formation was not struck. In Huron county Lane makes the section 605 feet thick. Grabau estimates the thickness in the vicinity of Alpena, 403 feet in depth.

15. *Dundee or Corniferous.*

This limestone is buff, yellowish, or almost white in color, and is the lowest formation shown in the South Bay City well. The drillings indicate a uniform yellow colored limestone from 3,270 down to 3,508 feet, without disclosing any change that could be noted to Monroe dolomites.



LOCATION OF DRILL HOLES FOR COAL IN T. 13 N., R. 4 E.

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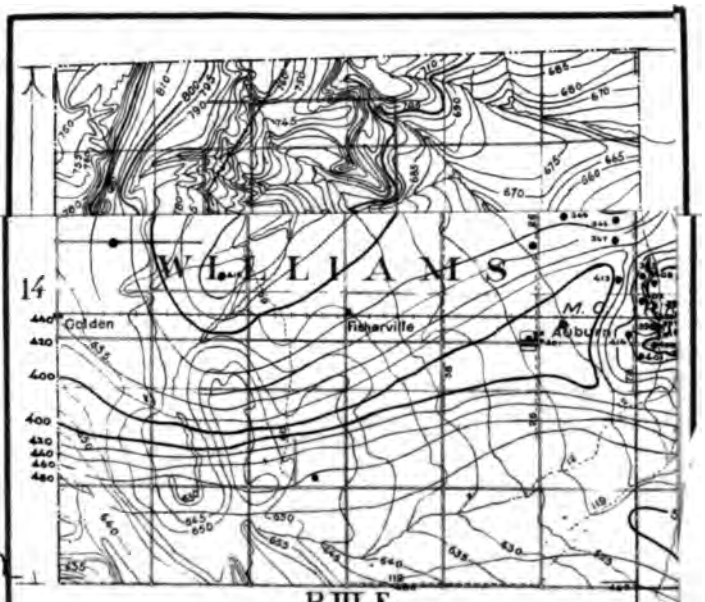

FOR TEST HOLE LOCATIONS IN
T. 13 N. R 4 E. ~~SEE PLATE V.~~
SEE PLATE V.

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age valley near the west end, and the succession of the strata in the coal formation underneath South Bay City and eastward. The section E-F extending through Bay City, runs southeast and is instructive as showing the comparative absence of coal where heavy beds of sandstone are laid down. The last section, G-H, extends from the Amelith shaft before mentioned, through the mine now known as Wolverine No. 2 in Monitor township.

2. *History of Coal Development.*

In an instructive pamphlet by the late Chas. B. Schaefer, editor of the "Michigan Miner," entitled "The Coal fields of Bay County," there is considerable information given relative to the development of coal mining in this district. From this it appears according to the testimony of Capt. Boutell, that the first discovery of coal in Bay City was made by Wm. Walker, a well borer, who came there in 1861 for the purpose of putting down a salt well on the property where the Michigan Pipe company's plant now stands. "The discovery created considerable interest at the time, but nothing was done about the matter, as the people were anxious to find salt, and there was an unlimited supply of cheap fuel to be had anyway." With the decline in the lumber industry, and the development of the manufacturing resources in the Saginaw valley, the future development of the coal industry was assured. When, in 1893 coal was discovered, while putting down a well for water at a saw mill owned by Zill Bros. in Monitor township, five miles west of West Bay City; the discovery was followed up by a company organized at the suggestion of Alex. Zagelmeyer. To him and to Frank Zagelmeyer, is due in great part, the credit of developing the mining industry in Bay county. Land was leased from Zill Brothers, and after the basin had been drilled by Goff Paul, a shaft was sunk in the summer of 1895, in spite of the many obstacles to be overcome, and public prejudice. This was followed during the summer of 1896, by the sinking of the shaft of Bay Mine No. 1, situated just east of the former shaft. This was shortly followed by shafts sunk by the Michigan Coal and Mining Co., Mr. J. A. Etzold former president, and by the Central Coal and Mining Co. (Sec. 25 T. 14 N., R. 4 E.), of which Mr. W. A. Knapp was Secretary and Treasurer. At about the same time Handy Brothers' mine, now abandoned, but known as Wolverine No. 1, and the shaft of the Wenona Coal and Mining Co. were put down near Oatka beach. During the winter of 1899-1900 the shaft of Bay Mine No. 2 was put down by Alex. Zagelmeyer. In the summer of 1900 the shaft of the Pittsburg Coal Co. was sunk near the Amelith P. O., under the direction of Mr. John Werner. At the same time the shaft of Wolverine No. 2 Mine was sunk by a stock company of which Leonard Zill and John S. Wuepper were the active agents. As will be seen, the exploitation of the different coal basins in Bay county is largely due to the intelligent and conscientious efforts of Mr. Zill. Later developments of the coal industry in Bay county, have resulted in the development of the mine of the Salzburg Coal Co., prospected by Leonard Zill, and opened in 1902. At about the same time, the shaft of Wolverine No. 3 Mine was opened by Handy Brothers in the northeastern part of Williams township. I believe also the shaft of the New Central Mine was started in 1902. The shaft of the Hecla Portland Cement and Coal Co. in Frankenlust township was also put down in 1902.

I am indebted to different operators and drillers for information regarding the workable coal deposits in the lower third of the county. To Mr. John

H. Werner, the Survey is under obligations for the records southeast of Amelith in Frankenlust township. Mr. Werner has also given the Survey the record of several holes south of Wolverine No. 2 shaft. I understand that the greater part of this drilling was done by Mr. Ward. Mr. John H. Metcalf of Bay City has given numerous records of drilling operations on land leased by the Valley Coal Co. Mr. Ubald R. Loranger has very generously contributed a blue print showing the location of numerous test holes in the northeast part of Frankenlust township and the southeast part of Monitor township, around the shaft of the Hecla Co. I believe that this drilling was done by McIntosh and Wampler, but the records were obtained from Mr. Etzold. He has also donated to the survey several records of the Michigan Coal and Mining Co., while from the adjoining property on the east, controlled by the Central Coal Mining Co., information was obtained from Mr. Chas. Coryell of Bay City. The Survey is greatly indebted to Mr. Leonard Zill for numerous records in Monitor township, besides several additional records in other parts of the county. Mr. Goff Paul of West Bay City has also given the results of his work around Bay City, West Bay City, Bangor and Monitor townships. As a result of this exploitation, the abandoned mine of Handy Brothers, afterward called Wolverine No. 1, and the old Monitor shaft were opened. Mr. W. L. Ralston and A. J. Wampler have also done considerable drilling for the Sage Land and Improvement Co. and other parties. Finally I wish to express my indebtedness to Theodore Archambeau, Mr. William Penniman, F. J. Tromble, and O. W. Blodgett for numerous scattered records, the latter for the most part being from Merritt township. More recently, Mr. Wampler has sent in valuable records from the western and northern part of the county, which have been of great value to us.

3. *Drift Filled Channels.*

By this is meant the former drainage channels on the top of the coal formation, before the present drift or overburden was brought down by the ice sheet and deposited, smoothing over all inequalities in the underlying bed rock. This earlier drainage system trends to the west and southwest, into a main channel probably meandering from Saginaw westward through St. Louis and Alma.

The Amelith Washout.

In the report of Mr. Lane on Huron county, and in his report on "Coal," one of these early, or pre-glacial drainage channels is described as leaving the southwest corner of Huron county; he supposed it to pass near Unionville in Tuscola, and thence west and south through Portsmouth and Frankenlust townships, into Saginaw county. As a result of rather numerous well and test hole records for coal, I have been unable to locate any such washout in that part of this county. Either the old drainage channel from Unionville passes south into Saginaw county, or else, which is more likely perhaps, it takes a westerly course across the lower portion of Saginaw bay, entering Bay county near the mouth of the Saginaw river. From here a pre-glacial drainage course is well marked, passing south of Handy's abandoned mine, where the descent is abrupt, the former topography apparently being not unlike that of the Kentucky coal fields *or the* arroya region of the west. At the shaft of Wolverine Mine No. 1, *there is 72 feet of clay drift.* Within 80 rods to the south, this buried chan-

nel is filled with over 178 feet of alternating deposits of clay, hardpan, quicksand and gravel, the rock not being struck. The elevation of the rock surface, however, is probably not far from 400 feet A. T., or 180 feet below the level of Saginaw bay. This buried channel descends more abruptly from the north side than from the south, which fact very likely is due to the shearing action of the ice. Both the Verne coals, as well as the overlying Salzburg coal, are eroded away in this buried drainage channel throughout its extent in Bay county. Eighty rods south of the north line of section 9, in the same township, the amount of drift has decreased to 90 feet on the south side of this preglacial valley. From here the course was in a southwesterly direction, entering Monitor township near the northeast corner of section 13, T. 14 N., R. 4 E. A well record in section 7, T. 14 N., R. 5 E., gives the side of the valley there an elevation of 420 feet A. T. Drill records furnished by Mr. Amos J. Wampler in section 12, T. 14 N., R. 4 E., indicate that the rock elevation increases from 480 to 533 feet A. T., going towards Kawkawlin village, and on the north side of the valley, the amount of the drift being respectively 58 and 116 feet in thickness. Southward, near the east quarter post of section 13, T. 14 N., R. 4 E., there is about 86 feet of drift. Apparently the course from here was southward through sections 13, 23, 24, 26, 34, 35, of T. 14 N., R. 4 E., and thence southwest through section 3, T. 13 N., R. 4 E., swinging westerly in sections 7, 8, 9 of the same township. At Denekes, in the northeast quarter of section 35, Monitor township, there is said to be over 175 feet of drift below the elevation there of about 600 feet A. T. In the southwest ¼ of section 3, T. 13 N., R. 4 E., there is over 190 feet of drift at an elevation of 595 feet A. T. Just northwest at the shaft house of Bay No. 2, this has decreased to 111 feet, with 108 feet of drift in the center of the same section. On the opposite, or south side of this preglacial valley, the test holes northwest of the shaft of the Pittsburg Coal Co. near Amelith P. O., show 132 feet of drift in the N. W. ¼ of the N. W. ¼ section 15, T. 13 N., R. 4 E., and 168 feet near the southwest corner of section 10, T. 13 N., R. 4 E. The elevation of both these holes is nearly 607 feet A. T. The geological cross sections C-D and G-H, both indicate this buried valley. From between the two shaft holes of the Pittsburg and Bay No. 2 mines, the course of the former drainage was probably west into Tittabawassee township, Saginaw county, but it is not impossible that the course may have continued to the southward, through sections 16 or 17 of Frankenlust. There are indications of a washout north of West Saginaw, with which this may be connected. Amelith P. O. being situated on the east side of this washout, I would suggest that this name be applied to the same.

The Auburn Washout.

This name is given to designate a depressed early topographic area, or perhaps more properly a subordinate valley region, which I believe heads in east and somewhat south of Auburn village. At first I was of the opinion that this connected with the washout probably running down near Amelith, but recent drilling by Mr. Wampler in sections 21 and 22 of Monitor, and information previously obtained in section 28 go against this conclusion. This line of lowest rock elevation probably heads in near the corner of sections 21, 22, 27, 28, thence running westward near the north line of sections 28, 29, and 30 of Monitor township, underneath Auburn village, and thence probably westward and south of the Midland stone road.

Near the western line of the county, this Auburn washout probably unites with one coming down through Beaver township. There is also a lateral drainage area trending northeast from Auburn which runs through sections 18 and 8 of Monitor between Wolverine mines No. 2 and 3.

At Auburn Mr. Wm. Everett after drilling 220 feet, struck the rock at an elevation of 397 feet A. T. The top 65 feet were clay deposits, the underlying beds being alternating strata of sand and gravel, with thin layers of clay. One mile and a half north there is only 124 feet of drift, while at North Williams, one mile west, the amount of drift is 110 feet. Southwest from here in the southeast quarter of section 17, there is only 87 feet of drift where the surface elevation is 643 feet A. T., making the rock elevation there 556 feet high. I believe that this very considerable rock elevation trends northeast. West from this last location, and on the county line, there is 197 feet of drift near the northwest corner of section 19, the distance to bed rock increasing to the northward, as we shall see in investigating the Beaver washout. Near the southeast corner of section 13 of Williams, test hole 413, bed rock is struck at 407 feet A. T., the drift rapidly decreasing in thickness to the north and east, as shown by test hole records 366 and 385. In the northeast quarter of section 18, Monitor, there is over 170 feet of drift which decreases in thickness to the north and east. An examination of our rock contour map will serve to show how the depth to bed rock increases south of Wolverine mine No. 2, and south of the new Auburn shaft in the northwest quarter of section 19, Monitor township.

The Beaver Washout.

This has been designated thus on account of its very pronounced development in the central and southwestern part of Beaver township. It probably heads in the north central part of Frazer township, and has a southwesterly course through the southeastern part of Garfield township, thence running south and west through the central and southern part of Beaver, T. 15 N., R. 3 E. This channel probably unites with the Auburn washout, east of Midland. In section 33 of Beaver there is over 225 feet of drift, and no rock struck at 400 feet A. T. In the northwest quarter of section 21, near Kimmel's store, it is 227 feet to rock which is at very nearly 400 feet A. T. At test hole 453 in the west half of section 23, rock is struck at 445 feet A. T., with 168 feet of drift. Northward from here in section 7 of Beaver, the rock was struck at 530 feet A. T.; 119 feet of drift. Thence northeast, four test holes for coal recently put down by Mr. Wampler in the south half of sections 32 and 33, Garfield township have from 144 to 180 feet of drift, the greatest amount being in the southwest quarter of section 32. East and south of here, just over the township line in Beaver, Wampler went through 185 feet of drift in section 3, and 162 feet in the northwest quarter of 2, the surface elevations being about 630 feet A. T. The bed rock divide probably runs between these two last groups of holes into section 7. Additional information in section 30 of Fraser and 24 of Garfield, near the township line, show a very considerable decrease of thickness of the drift to the northeast in this washout.

The Souwestconing Washout.

This probably starts not far from the center of Bay City, extending past the Middle Ground, and thence south and west of Souwestconing creek into Saginaw county. There are no data to indicate the precise limits of this

course on its east side. Other records of test holes for coal, and occasional well records, would place the course of this early drainage valley south and east of the Valley mine and east of the shaft of the Pittsburg Coal Co. near Amelith. This area may be prolonged into the heavy drift filled channel north of West Saginaw. In this, as in the other areas of bedrock erosion, the Verne coals and the overlying Salzburg coal have been largely removed, and we may also find the Saginaw coal occasionally absent.

East of the Saginaw river the elevation of the rock surface, as far as our records show, is almost uniformly at 500 feet A. T., excepting for a small area west of Munger, where the rock falls off to the westward.

West of Saginaw bay and the Saginaw river, the elevation of the bed rock divide east of the former drainage channel in Beaver township is 540 feet A. T., this area extending at least half way across Williams township, and within two miles of the Midland county line. Thence the general course is northeast and north, the eastern front trending in a general way with the present shore line of Saginaw bay.

The 560 foot rock contour line is of interest as containing a lesser accumulation of drift on its surface, than any other portion of Bay county. In the northern part of Fraser township, there are two well records collected by Mr. W. T. Shaw, which show from 28 to 30 feet of drift. Northward from here, there are comparatively few data available in this county. W. M. Gregory, however, has shown that the rock surface rises to the north, in several places reaching the surface in Arenac county. A well put down by W. H. Hinman at Bently entered the rock at 620 feet A. T., which corresponds in a general way with the rock elevation farther east, in the adjoining county where the surface elevation is much lower. If the bed rock at Bently were down on the shore of Saginaw bay, we would have a rock bluff 40 feet high. As can be imagined, this would form quite a striking contrast with the present topography. On the other hand, the lowest bed rock elevation in the west central part of Beaver is some 180 feet below the lower reaches of Saginaw bay, giving a difference of at least 220 feet of rock elevation. The difference of surface elevation is about 250 feet. Further changes in our ideas of the bed rock elevation will doubtless result from future investigation, especially in the western tier of townships, but I trust we have been able to indicate the main courses of washouts with some degree of accuracy.

4. *Horsebacks, Sandstone Channels and Areas.*

As defined by Lane a horseback is a rising up of the foot wall, or strata underneath the coal, forming a roll which affects the overlying coal seam. Reversely, we have sandstone channels which occasionally come in from the top, and cut out to a greater or less degree the underlying coal seam. Horseback formations are often met with in the Bay county mines. Where the drifts or entries are run at angles to these horsebacks, there is considerable dead work, both in mining, track laying, and drainage. It is therefore advisable to run parallel to the crest of the horseback. An ideal way in which this operation has been carried on is seen in the mine of the Central Coal Mining Co., section 25, T. 14 N., R. 4 E.

In Volume VIII, part 2, Lane has described several localities in which the seams of coal are cut out by beds of compact sandstone. These may be likened to the washouts described in the preceding pages, except that the material has become consolidated in a manner similar to the associated beds.

In Bay county there is only one mine which shows sandstone beds cutting out seams which are being operated. It is doubtless true, however, that the deposition of irregular areas of sandstone has affected to a greater or less extent the accumulation of workable coal areas. In the Amelith coal field, operated by the Pittsburg Coal Co., the main sandstone area trends east and west. In one such sandstone belt extending through the south half of the north half of section 15, T. 13 N., R. 4 E., there are two seams of coal represented, and from three to four strata of sandstone. In the area adjoining on the south, and approximately adjacent to the east and west quarter line of the same section, there are from two to three layers of coal and one sandstone horizon is occasionally represented. In the former area 6% of the test hole records are composed of sandstone strata in nine holes having an aggregate depth of 1,861 feet, while in the area adjacent to the quarter line, the amount of sandstone has decreased to 1⅓% in 11 holes with a total depth of 2,252 feet. The coal strata amount to 1⅓% and 2 2-9% respectively, in these two areas. It was also determined that while the amount of sandstone decreased 4⅓%, that the amount of coal strata increased 5-9 of 1% in the same area to the south. This information is compiled from the record of twenty test holes having an average depth of 205 feet. In the section A-B, the coal is represented overlying a slight sandstone fold, probably trending in the same east and west direction.

The records of the territory leased by the Hecla Portland Cement and Coal Co., are not distributed in such a manner as to permit of any general deductions being made. There are indications, however, of a sandstone area running northwest and southeast in the east half of section 2, T. 13 N., R. 4 E. This area is bounded by a coal belt very nearly 80 rods wide, in which there is an entire absence of arenaceous strata at the same depth. Again to the south and west, beds of sandstone reappear at irregular elevations, being succeeded farther on by test holes in which the entire section is composed of coal and shale. In the southwest quarter of section 11, the beds of sandstone again reappear in a single record obtained there.

East from here in the territory drilled by the Valley Mine Co., the records are rather scattered. In a group of test holes near the line of sections 6 and 7, T. 13 N., R. 5 E., there are two horizons of sandstone strata which extend northwest and southwest into sections 1 and 12, T. 13 N., R. 4 E., and may embrace the sandstone area previously described in the east half of section 2, T. 13 N., R. 4 E. In the northeast quarter of section 1 there are only two holes with thin beds of sandstone out of 12 drill records. The deposition of the coal and sandstone beds here would rather indicate an east and west direction, in which the sandstone area spread out to the west like the flutings of a fan, embracing swales, from which coal alone is obtained down to a depth represented by the sandrock beds farther east. These swales would be represented by the coal and shale areas of the Hecla property.

Another series of test holes in section 33, T. 14 N., R. 4 E., and additional records around the shaft of the Monitor Coal Co. in section 28, bring out the same general trend of the sandstone strata. In this section there are from 4 to 6 feet of sandstone at depths varying from 101 to 106 feet, but at very nearly the same elevation above tide. This is very likely along the strike of the sandrock which extends N. 50° E., for about one mile, as far as our records indicate. If this area be extended N. 66° E., into the north half of section 25, T. 14 N., R. 4 E., similar associated beds of sandstone and coal are found replacing the main workable coal beds. This area in

section 25, is separated from a like deposit in the S. E. ¼ of the S. E. ¼ of the same section, by coal and shale bearing beds of workable thickness, in which the sandstone beds are absent at the same depth. In the area in the north quarter of section 33, and the south quarter of section 28, T. 14 N., R. 4 E., the bed of sandrock deposited farther south is not represented in the test holes for coal, which is of a workable thickness. Carrying the parallel northward, the records again show associated beds of sandstone and coal in the S. E. quarter of sections 29 and 22, T. 14 N., R. 4 E., which may represent another belt of sandstone sediments.

In the territory contiguous to Wolverine shaft No. 3, we have the records of 14 test holes for coal which were drilled in the eastern part of sections 12 and 13, T. 14 N., R. 3 E., and in sections 7 and 18 of T. 14 N., R. 4 E. Taken as a whole the entire area, beginning at the south, shows an alternation of shale and sandstone beds, and the latter extend in two parallel belts running east-northeast, being replaced by beds of shale in the intervening areas. The coal seams are quite persistent throughout three-fourths of the entire area. The different beds of sandstone tend to recur within the same belts, being interrupted in their horizontal extension north and south as noted above. Beginning at the south, the records of four drill holes having an average depth of 214 feet, show 44 feet of sandstone and 23 feet of coal. Expressed in percentages, this would respectively amount to 5¼ and 2 7-10 of sandstone and coal. In the next area adjoining on the north there are two test holes with an average depth of 193 feet and containing 15 feet or 4% of coal beds and no sandstone. Succeeding this, we have four records with an average depth of 186 feet and showing 28 feet of sandstone and 31 feet of coal, or approximately 5% of each. In the farthest area to the north there are four holes averaging 223 feet deep, and containing 5% of coal strata and no sandrock.

The records of 21 drill holes in T. 13 N., R. 6 E.; of 37 records in T. 14 N., R. 5 E., and 19 holes in sections 13 and 24, T. 15 N., R. 4 E., and in sections 19 and 30, T. 15 N., R. 5 E., indicate for the most part heavy beds of sandstone and shale, with scarcely any workable beds of coal. How wide this belt of sandstone sediments is has not been determined. The western side seems to extend toward the northwest in an irregular manner, very likely conforming to the shoreline of the coal measure sea.

Recent investigations near Salzburg show a sandstone channel running north-northeast, entirely cutting out the coal for a distance of about 80 feet east and west, the coal reappearing on the west side of the sandstone cut out or belt. The sandstone cuts in from the top, displacing the coal stratum, which feathers out below the sandrock. On the east side of the workable coal beds the coal is again cut out by a bed of fire clay coming in from the top, quite similarly to that of the sandstone beds to the westward. The fire clay and sandrock seem to merge into each other farther south, enclosing a U or V shaped area which opens out to the north-northeast.

In sections 17-21 of Monitor township, T. 14 N., R. 4 E., there are some four or five beds of sandstone rather irregularly distributed. With the lowest bed the greatest extent is east and west, the same bed reappearing at about half the distance to the north and south. In the intermediate areas the coal is deposited in greater amounts than where the sandstone is laid down, but at the same time there may be a workable bed of coal where sandstone has been deposited. The greater the amount of sandstone strata, the less of coal, but coal may also be deposited in small amounts where

there are no arenaceous strata. The same remarks concerning the upper beds of sandstone, as far as represented, hold for this area.

Altogether these areas of sandstone have in general an easterly trend forming folds and flutings, which enclose estuaries and inlets, in which the coal was generally deposited in greater quantities than in the intervening areas. As will be seen, however, coal beds of equal thickness were sometimes laid down regardless of local irregularities.

5. *Boiler Tests. Coal Analyses.*

There are some 12 strata of coal represented in this formation in Bay county. Analyses have only been obtained from four layers. It would undoubtedly be of great benefit if coal drillers kept samples from each seam of every test hole put down, care being taken to have a clean sample of all the drillings from the entire layer. While coal seams are too thin to work in places, they show local thickenings in adjacent localities, and analyses taken from different places would give a truer idea of their value than an isolated determination. Moreover, comparative analyses of the lower seams would very probably be an aid in correlating the different layers, as in the case of the two Verne coals.

In testing coal to determine its value for heating and boiler purposes, the result is stated in British Thermal Units (B. T. U.). By this is meant the number of pounds of water which one pound of fuel will raise one degree F. This equals 778 ft. pounds. "The heating power may be very closely computed from what is known as an ultimate analysis (where the percentage of each element or atom, instead of the molecule is given), and Dulong's formula gives as good results as any," to wit: (146 x % carbon) + [620 x (% hydrogen — $\frac{1}{8}$ oxygen)] + (40 x % sulphur). In this equation the three factors are to be considered separately and then added; that is the amount of carbon is to be multiplied by 146 giving result one. The amount of hydrogen must be subtracted by $\frac{1}{8}$ of the percentage of oxygen, and the result multiplied by 620 giving us result two. Finally the percentage or amount of sulphur multiplied by 40 gives us result three; which added to the two preceding results gives the equivalent in B. T. U.

Mr. Lane has determined the following formula from what is known as a proximate analysis, where the results are stated as so much moisture, fixed carbon, volatile combustible matter, etc.: B. T. U. = (146.6 x % combustible) + (40 x % sulphur). By the per cent of combustible in the first equation, is of course understood the amount of fixed carbon, and volatile combustible matter. These two are to be added and the result multiplied by 146.6 giving result one. The amount of sulphur multiplied by 40 gives result two. The total of these two results gives the equivalent in B. T. U. We will now proceed to give the results of some analyses of Bay county coals and their equivalent in B. T. U., as near as the accuracy of the sample and analysis permit. The analyses are classified by the layers of coal, from which the sample was obtained. Most of them are from the Upper Verne.

Mr. A. S. Ruttle of the Wenona Coal and Mining Co., has given the result of an analysis of the Saginaw seam in the southwestern part of Merritt township. I believe that the sample was obtained from a drill hole. The amount of volatile combustible is not stated separately. If this runs sufficiently high, the coal would very likely be well adapted for burning cement clinker, taking into account the very small amount of sulphur contained in the coal.

Saginaw Seam. What Cheer Mining Co.

Moisture	2.864
Ash	5.853
Combustible	91.283
	100.000
Total sulphur	0.1278
B. T. U., computed	13,382.6

Lower Verne. Michigan Coal & Mining Co.

Moisture	5.01
Vol. matter	39.62
Fixed carbon	41.67
Ash	13.70
	100.00
Specific gravity	1.33
Total sulphur	6.66
Vol. sulphur	6.37
Sulphur in Ash	0.29
B. T. U., computed	12,183.514

Lower Verne. Michigan Coal & Mining Co.

	Ultimate Analysis.	
	Moist Coal.	Dry Coal.
Water	5.01	.....
Carbon	62.29	65.57
Hydrogen	4.62	4.87
Nitrogen	1.20	1.26
Oxygen	6.81	7.17
Ash	13.70	14.42
Vol. sulphur	6.37	6.71
	100.00	100.00

B. T. U., Moist Coal, 11,686.54, computed. This is approximately 696 B. T. U. less than shown by the proximate analysis.

We next give proximate analysis from the Central Coal and Mining Co., located within half a mile of the above mine. The sample, however, is from the Upper Verne seam.

Upper Verne. Central Coal & Mining Co.

Sp. Gr	1.36
Moisture	4.52
Vol. combustible	40.57
Fixed carbon	42.16
Ash	12.75
	99.36

B. T. U. 12,128.218, computed. This mine is located about two miles east-northeast of the Valley Mine, which analysis follows:—

	Upper Verne. Valley Mine.
Moisture	1.7%
Ash	9.5
Vol. matter	35.5
Fixed carbon	53.3
	100.00

B. T. U., 12,918.0, computed. Analysis by C. A. Davis.

We next have two analyses by Lathbury and Spackman, furnished us by U. R. Loranger of Bay City. They are from the drillings of the Upper Verne (?) seam, on the Goetz property in section 36 of Monitor township, and about one mile north of the Valley Mine.

	Upper Verne (?). Goetz Coal No. 1.
Moisture	3.76
Vol. combustible	37.05
Fixed carbon	50.10
Ash	9.09
	100.00
Sulphur	3.72
B. T. U., computed	12,924.990

	Upper Verne (?). Goetz Coal No. 2.
Moisture	6.50
Vol. combustible	33.98
Fixed carbon	40.60
Ash	18.92
	100.00
Sulphur	1.79
B. T. U., computed	11,005.028

Within three miles to the west of the Goetz coal, we have the Upper Verne represented at the Old Monitor Mine in the S. E. ¼ of section 28, Monitor township.

	Upper Verne. Old Monitor Mine.
Moisture	10.03
Vol. combustible	35.36
Fixed carbon	49.94
Ash	4.67
	100.00
Sulphur	1.12

Analysis by Lathbury and Spackman, from U. R. Loranger. B. T. U., 12,594.58, computed.

The two following analyses are from the Upper Verne at Wolverine Mine No. 2. This is located at less than two and one-half miles north-northwest of the Old Monitor shaft hole. The first analysis was made by Dickman and Mackenzie for Wicks Bros. The sample is from car load lots; dried at 212° F. The second analysis is from R. M. Randall of the Saginaw Coal Co.

Upper Verne. Wolverine No. 2.

	No. 1.	No. 2.
Moisture	6.76	6.18
Volatile combustible	42.67	46.10
Fixed carbon	42.01	40.88
Ash	8.65	6.84
	100.10	100.00
Sulphur	3.50	2.27
Iron Met		2.54

B. T. U., Wickes Bros., 12,295, R. M. Randall, 13,335.
B. T. U., Geol. Surv., 12,556, Geol. Survey, 12,842, computed.

We also have another analysis from Wolverine No. 2; analyst, L. Kirschbraum, University of Michigan.

Upper Verne. Wolverine No. 2.

Moisture	8.92
Vol. combustible	36.49
Fixed Carbon	51.92
Ash	2.67
	100.00
Sulphur	1.49
B. T. U., computed	12,987.506

Two and one-half miles northwest from this last locality is Wolverine No. 3 Mine, from which Mr. R. M. Randall has sent us the following. I believe that both the Upper and Lower Verne are represented in this mine, separated by a thin bed of shale. This analysis is probably from the upper bed.

Upper Verne (?). Wolverine No. 3.

Moisture	4.14
Vol. hydrocarbons	45.70
Fixed carbon	42.14
Ash	8.02
	100.00
Sulphur	3.53
Iron Met	3.30

B. T. U., per pound, 12,519.8, R. M. Randall.
B. T. U., per pound, 12,912.464, computed.

We next have analyses of the Upper Verne from the Wenona Mine, north of West Bay City.

Upper Verne. Wenona Mine.

Moisture	2.06
Vol. combustible	41.40
Fixed carbon	51.89
Ash	4.65
	100.00

B. T. U., 13,676.314, computed.

The following analysis by Prof. Geo. A. Koenig of the Mich. School of Mines, was made in August, 1899:

Carbon	72.74
Hydrogen	5.27
Oxygen	12.26
Nitrogen	1.51
Iron sulphide	3.66
Clay	3.47
Moisture	1.09
	100 00

Sulphur, 1.95%. Iron, 1.71.
B. T. U., 13,016.84, computed.

Mr. Henry J. Williams of Boston made the following analyses from the upper seam of the same mine.

	Wet coal.	Dry coal.
Moisture	3.98	....
Carbon	73.09	76.12
Hydrogen	5.03	5.24
Nitrogen	1.31	1.36
Oxygen	8.86	9.23
Ash	5.70	5.94
Volatile sulphur	2.03	2.11
	100.00	100.00

Total sulphur, 2.50.
Sulphur in ash, 0.47.

This coal yields by calorimeter test 13.489 B. T. U. per lb. of the wet coal and 14.048 per lb. of the dry coal.

A coke analysis of the same coal by D. P. Shuler runs as follows:

Moisture	1.68
Volatile matter	3.12
Fixed carbon	79.46
Ash	15.74
	100.00

Sulphur, 1.41. Phos., 0.01.

Mr. L. Kirschbraum of the University of Michigan, has made the following analysis from the split of the Upper Verne seam at the Salzburg mine. It is noteworthy on account of the small amount of sulphur.

Upper Verne Split or Rider. West Bay City.

Moisture	6.50
Vol. combustible	43.61
Fixed combustible	47.82
Ash	2.07
	100.00
Sulphur	0.89

B. T. U., 13,439.238, computed.

Finally we have an analysis by C. A. Davis of what I believe to be a drift coal from the northeast quarter of section 22, T. 13 N., R. 6 E.

Drift Coal. Merritt Township.

Volatile matter	59.20
Ash (gray)	8.58
Fixed carbon	32.22
	100.00

B. T. U., 13,402.172, computed.

Chas. H. Hilton of the Michigan Agricultural College has made the following determination for sulphur and iron from the property of the Michigan Coal & Mining Co., Monitor township. This is from the Lower Verne seam. We also have original analysis from H. S. Williams, for comparison, as follows:

Michigan Coal Mining Co.

	Williams.	Hilton.
Total sulphur	5.72	5.80
Sulphur in ash	0.04	0.05
Volatile sulphur	5.68	5.75
Iron	....	5.71
Sulphur computed from iron	....	6.52
Ash	8.26	8.33
Moisture and Vol. matter	45.68	41.39

We also have Hilton's determination from certain drillings taken from a test hole for coal in the S. E. ¼ of section 10 of Mt. Forest township, T. 17 N., R. 3 E., as follows:

Total sulphur	1.04
Sulphur in ash	0.03
Volatile sulphur	1.01
Iron	0.94
Sulphur computed from iron	1.074
Ash	12.23
Moisture and Vol. matter	38.59

Mr. Hilton's notes on his work follow:[3]

[3] Mich. Geol. Survey, Vol. VIII, part 2, p. 99.

"It will be noticed that the moisture and volatile are uniformly lower in my determinations than in the original analysis by Williams. Inasmuch as the amounts of these two factors had little bearing upon the present investigation, I made the determination of them together. To get at as to where the loss came in I made moisture determinations on three samples and found the loss of moisture accounted for the loss in the total moisture and volatile matter. Without going further, I took it for granted that the loss was thus accounted for in every case. The loss in moisture necessitates a higher proportion in the constituents, and I find accordingly larger percentages of total sulphur and of ash. The amount of sulphur in the ash is very small and is considered as sulphate in the coal. The amounts of volatile sulphur agree quite closely in the two sets of analyses."

"So far as the investigation has been carried the determination of iron has been the significant feature. I would call attention to the peculiar relation the content of iron bears to the content of sulphur. One varies as does the iron, and they stand in almost exactly the same relation to each other in every instance, viz., in combining proportion 5,664.12 to form iron pyrite (Fe S2)."

Conclusion.

"As we stated in the introduction, the work has not been carried to its farthest analysis, and whatever conclusions are drawn must be stated as strongly indicated and not as absolute or positively demonstrated. But there is a strong probability, amounting almost to a certainty, that the sulphur is all accounted for correctly."

"First: A small amount of sulphur is non-volatile, being formed as sulphate with calcium. Gypsum is found in perceptible amounts in coal deposits and the non-volatile sulphur is thus easily accounted for."

"Second: That the volatile sulphur is all combined with iron in the form of iron pyrite (Fe S2)."

"This second conclusion is given weight by the fact that in all the samples analyzed, all the sulphur and nearly all the iron are accounted for by combining them as Fe S2. It can easily be seen how, in one or two instances, these proportions would occur by accident and thus lead to erroneous conclusions. But it is extremely improbable that this accidental relation would occur in every case of samples of coal taken from eleven different mines in widely separated parts of the state. It seems just, therefore, to conclude that the volatile sulphur is rightly accounted for as Fe S2. This is not saying that the iron and sulphur were originally deposited in these proportions. But that does not concern this investigation. The present condition in the coal is what I am after."

Boiler Tests.

The following notes are taken from Mr. Lane's Coal Report:[4] We are indebted to Mr. Edgerton, superintendent of the electric light and waterworks plant, Lansing, for the tests given below: "In these tests a 12 hour run of coal was made to each coal, and an attempt was made to leave the grates in the same condition as they were found." "The amount of feed water was measured and the feed water kept at a constant temperature of 110° F." "The boiler pressure is nearly constant, about 95 pounds to the square inch, and the coal and ashes were weighed." "Of course there are many chances for inaccuracy." The boiler pressure was not absolutely

[4] Michigan Geol. Survey, Vol. VIII, part 2, pp. 69–72.

constant, the variations of atmospheric pressure and the temperature of escaping gases and the dryness of the steam was not noted, nor the coal which preceded on the grate, and this might make quite a difference.

Bay City, Upper Verne..... 7.56 units of evaporation
Bay City, Lower Verne..... 6.73 units of evaporation

During the third series of tests made during 1900 and 1901, the coal was taken from the Upper Verne seam at the Michigan Coal and Mining Co. (No. 1) and from the Stiver Mather Co., Valley mine (No. 2) of which an analysis has been given.

	1.	2.
Coal burned during test.....	14,626	15,916
Ash.....	1,255	3,180
Per cent ash.....	8.6	19.9
Lbs. of water at 62 lbs. per 1 cu. ft.....	95,604	93,310
Water evaporated with 1 pound of coal.....	6.536	5.846
Water evaporated for $1.00....	5,335	5,314

For further information on this section the reader is referred to Chapter IV of the report on Coal.[8]

6. *Coal Seams. Thickness of the Coal Formation.*

In his chapter on the "Occurrence of Coal," Mr. Lane made a provisional arrangement of the different coal horizons, to which the following names were given, beginning at the bottom: Lower coal, Lower Rider, Saginaw coal, Middle Rider, Lower Verne, Upper Verne, Upper Rider. I have found this arrangement to fit in very well with the test hole records obtained in this county, with the following additions: Bangor coal, Bangor Rider, Lower Verne Rider; the Salzburg coal and Rider over the Upper Rider of the Verne seams. We therefore have: Bangor coal, Bangor Rider, Lower coal, Lower Rider,[1] Saginaw coal, Middle Rider, Lower Verne and Rider, Upper Verne, Upper Rider, Salzburg coal, Salzburg Rider. It is not impossible that coal seams will be found overlying the Salzburg Rider. There is an indication of such a layer in the northern part of Bay county. The following test hole records will give an idea of the relationship of the different coal beds, beginning with the uppermost strata.

Clay.....	58		58	
Hardpan.....	20	6″	78	6″
Salzburg Rider.....		6″	79	
Fire clay.....	1		80	
Sand rock.....		8″	80	8″
Slate.....	8		88	8″
Salzburg coal.....	1	6″	90	2″
Fire clay.....	7		97	2″
Coal.....		8″	97	10″
Slate.....	6		103	10″
Fire clay.....	2	2″	106	

[8] Volume VIII, part 2, pp. 51–120.
[1] It is probable that what I call Lower coal is what Cooper calls Bangor coal in larger part.

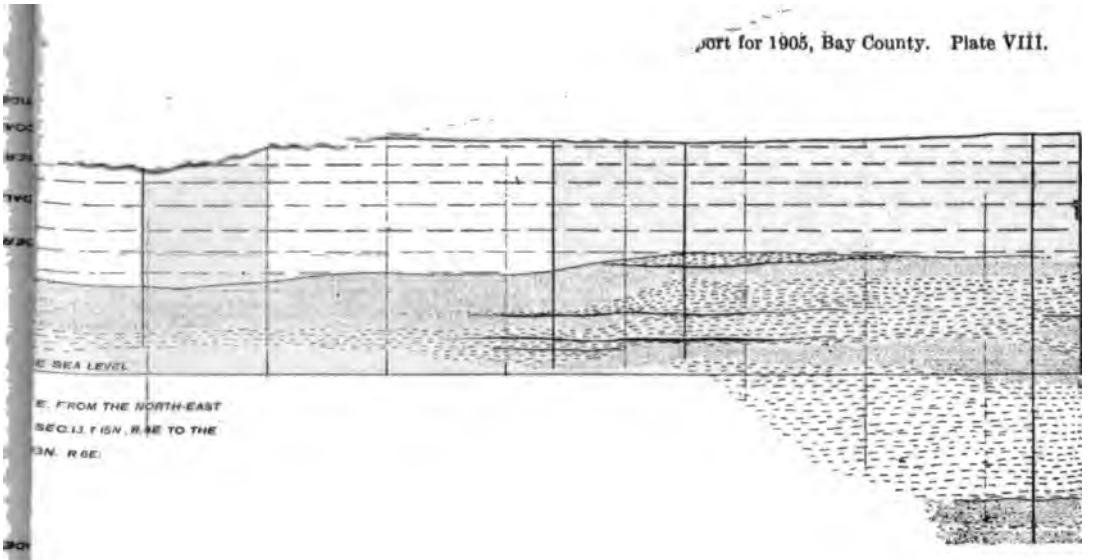
Slate		6″		106	6″
Upper Rider		8″		107	2″
Light slate	14			121	2″
Black slate	7	1″		128	3″
Upper Verne	2	7.5		130	10.5″
Fire clay	4			134	10.5″

The above record is near the Wolverine shaft No. 2. We next give a record from the south central part of Monitor township, carrying the coal formation down to the Saginaw seam.

Clay	78		78	
Sand	26		104	
Sandrock	2		106	
Upper Rider		8″	106	8″
Fire clay	10		116	8
Gray rock	9		125	8
Slate	5		130	8
Upper Verne		8	131	4
Slate	20		151	4
Fire clay	4		155	4
Slate	21		176	4
Lower Verne		3	176	7
Black slate	5	1	181	8
Middle Rider		6	182	2
Slate	7		189	2
Saginaw coal	1	7	190	9
Fire clay	2	4	193	1

In the S. W. ¼ of the S. E. ¼ of section 2, T. 13 N., R. 4 E., there is this log carrying the series on down through the Lower coal.

Sand and gravel	12		12	
Clay	42		54	
Hardpan	10		64	
Black slate	10		74	
Gray shale	32		106	
Sandy shale	18		124	
Upper Verne	2		126	
Fire clay	4		130	
Gray shale	22		152	
Lower Verne	1	8″	153	8″
Fire clay	3	4	157	
Dark gray shales	15		172	
Gray rock	5		177	
Saginaw coal	1	8	178	8
Fire clay	2	4	181	
Black slate	29		210	
Lower Rider		6	210	6
Slate and coal	2	3	212	9
Lower coal	2	3	215	
Fire clay	2		217	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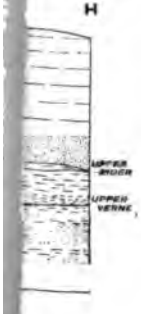
E. FROM THE NORTH-EAST
SEC. 13, T. 15N., R. 8E. TO THE
15N., R. 8E.

Plate IX.


H
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VERNE

We next have a test hole from Goff Paul, put down in Bangor township, which gives the two lowest coal beds yet found, and with the upper and middle beds but meagerly represented.

Sand	11		11	
Clay	71		82	
Hardpan	3		85	
Quicksand and gravel	5		90	
Quicksand and fine gravel with hard-pan streaks	70		160	
Slate	9		169	
Hard rock	6	3	175	3
Black slate	11	7	186	10
Saginaw coal ?	2	1	188	11
Fire clay	27		215	11
Slate, streaks of hard rock	60	4	276	3
Black slate	11		287	3
Hard rock	3		290	3
Black slate	4		294	3
Lower coal	1	2	295	5
Fire clay	30		325	5
Hard rock	2		327	5
Slate	20		347	5
Black slate	7		354	5
Bangor Rider		7	355	
Fire clay	18	7	373	7
Hard rock	4	8	378	3
Slate	22		400	3
Black slate	13		413	3
Bangor coal	1	9	415	
Fire clay	27		442	
Hard rock	23		465	

These records not only serve to show the succession of the different coal beds, but indicates in a very general way the absence of certain seams in other localities. If all the holes were of equal depth we would have better grounds for comparison.

The last test hole, however, does not give a complete idea of the thickness of the entire coal formation in Bay county. In the record of the deep well put down on the grounds of the North American Chemical Co. at South Bay City, by Thomas Percy, we have the following log, including the overlying drift.

Sand	15	15
Clay	35	50
Sand	10	60
Hardpan	10	70
Sand	30	100
Hardpan	38	138
Sand	2	140
Sandstone	138	278
Blue shale	17	295
Sandy shale	10	305
Blue shale	15	320

Sandy shale	5	325
Blue shale	35	360
Shale	60	420
Fire clay	10	430
Blue shale	30	460
Fire clay	10	470
Shale	10	480
Red shale	10	490
Parma sandstone	50	540

This would make the thickness of the Coal Measures 350 feet, the base of the coal formation being 90 feet A. T. The top strata have suffered considerably by erosion, which makes the thickness of the formation about 50 feet less than normal. At Bradley's deep well (record 359), the top of the Parma comes in at 367 feet or 216 feet A. T., showing how the basement, on which the coal formation rests, rises in that direction. To the west, a hole put down by W. L. Ralston in the center of section 4, T. 13 N., R. 4 E., enters at a depth of 409 feet, a conglomerate probably at the base of this formation, which extends to a depth of 450 feet. The drift here is 108 feet thick. Farther west at Midland, the drift is 285 and the Coal Measures 525 feet thick. The Parma also shows a thickness of 110 feet at a depth of 920 feet. Mr. Lane is of the opinion "that the rest of the strata shown in the Midland section are additions to the base of the Coal Measures, the elevation of the Verne coals being very nearly the same above tide at Smith's Crossing, four miles below Midland, and at Amelith in Bay county." A brief survey of the different coal horizons will now be in order. It is to be remembered that the correlations which follow are more of less doubtful, especially with the lower coal seams.

7. *Bangor Coal and Rider.*

The existence of this coal horizon is based on certain comparative data obtained from Goff Paul in sections 3 and 10 of Bangor township. The Saginaw coal is found there at a depth of 196 feet or 387 A. T. This is about 13 feet lower than its average elevation A. T. in Bay county. In test hole 273 this is underlain by the Lower Rider and Lower coal at the respective elevations of 332 and 267 feet A. T. In test hole 238 the Lower coal is found at 273 feet A. T., with what I have taken to be the rider of the Bangor coal at 266 A. T. In test hole 239 of section 3 Bangor, the Bangor coal rider is apparently struck at 248 feet A. T., depth 335 feet, the underlying Bangor seam being 192 feet A. T. at a depth of 391 feet. In the N. E. ¼ of the S. E. ¼ of section 13, T. 15 N., R. 4 E., I have identified the Bangor coal rider at a depth of 332 feet; elevation 252 feet A. T. In the diamond drill hole put down for Bradley in the southeast corner of Hampton township we have the Lower coal and rider at approximately the same elevation as already given for Bangor township. The Bangor coal rider is formed at a depth of 327 feet; elevation 256 feet A. T.; the Bangor coal at a depth of 360 feet and 222 A. T. This is only seven feet above the top of the Parma there. The accuracy of the Bradley record, and the relative elevation above tide of the Lower coal and its rider there, compared with the seams in Bangor township, together with the occurrence of these Bangor coals below, rather substantiates the existence of these seams.

The rider of the Bangor coal is found at from 56 to 60 feet higher in section

3 of Bangor township, T. 14 N., R. 5 E. At Bradley's well there is apparently only 33 feet separating the two horizons. It is probable that the relatively low elevation above tide here, is due to the decreased amount of sedimentation between and underlying these two coal beds. In section 13 of Kawkawlin, the Bangor Rider is in much the same position as Bradley's hole, in reference to the center of the coal basin.

These two coal horizons have in general a foot composed of fire clay, and a roof of black slate, or more properly shale. Should this coal prove suitable for industrial purposes, the time may come when it could be profitably mined with the underlying fire clay.

8. *Lower Coal and Rider.*

Reference has already been made to these two horizons in the sections printed at the beginning of this chapter. In the drill records which I obtained in Bay county, the lower seam was encountered in 21 drill holes. This lower layer in townships 13-15 N., R. 5 E., is found in general at an elevation of from 266 to 295 feet above tide, and at depths varying from 268 to 317 feet. In Monitor township, T. 14 N., R. 4 E., the elevation above sea level varies from 356-376 in the northwestern part of the township, being found at an average depth of 240 feet below the surface. This coal seam apparently shows a continual increase in elevation from the west quarter post of section 16, T. 14 N., R. 4 E., to the southwest quarter of section 6, of the same township. At Bradley's hole in the southeast corner of Hampton township, the elevation of this horizon is apparently 290 feet above sea level. This would rather indicate that the filling up process, by which the coal formation accumulated, extended this far east. We would thus expect this layer to be found at approximately the same elevation above tide between the Bay-Tuscola county line and Bay City.

The rider of this horizon is from 57 to 79 feet above the mother seam, in T. 14 N., R. 5 E. At Bradley's well the rider is but 36 feet higher, which probably indicates that the filling in of the coal basin had lapsed during the period when the intermediate strata were laid down. As we have seen, this is what took place during the deposition of the Bangor coal, the Bangor rider, and the strata below, the aggregate result being a very considerably thicker formation in the vicinity of Midland. In sections 6 and 7, T. 14 N., R. 4 E., the rider of the Lower coal is from 9 to 15 feet above the seam below. The considerable lapse in deposition here was apparently continuous through Verne times, throwing the entire formation there to a much greater, than normal depth. Such local depressions are not generally so persistent.

The thickness of the Lower coal varies from one to three feet. The average for 11 holes in the north half of T. 14 N., R. 5 E., is very nearly two feet. Eighty rods north of the south quarter post of section 10, T. 14 N., R. 5 E., there is three feet and one inch of coal at a depth of 310 feet, belonging to this horizon.

In the records of 17 drill holes, the Lower coal is underlain by fire clay in 15 holes, the foot of the other two being composed of sandstone and slate. The roof is of shale or slate. The thickness of the roof and foot varies very considerably in the different records. The rider is overlain by slate, and underlain by fire clay, with the exception of three holes, where the foot is of sandstone. There are 12 test holes in which this rider is apparently represented.

Since the above was written Mr. Amos Wampler has sent in the record of a test hole in the southwest quarter of section 20, T. 14 N., R. 4 E., in which the Lower coal is two inches thick at a depth of 231 feet and 327 feet A. T. He has also sent in the record of a test hole near Loehne P. O. and additional records near the Beaver-Garfield township line; from section 24 of Garfield and 30 of Fraser, which show heavy beds of sandstone and shale coming in at about the depth at which I believe the Lower coal should be found.

9. *Saginaw Coal and Middle Rider.*

These two coal horizons have been identified in the records of 70 drill holes obtained in Bay county. The average elevation of the Saginaw coal is 400 feet above sea level, the extremes of variation oscillating between 350 and 438 feet. In T. 13 N., R. 4 E., T. 13 N., R. 6 E., and T. 14 N., R. 3 E., the average elevation runs close to 400 feet A. T., in T. 14 N., R. 4 E., the height is 413 feet above sea level, with an elevation of 389 feet in T. 14 N., R. 5 E. By determining the elevation of the surface above sea level from the contour map in this report, and subtracting the elevation of this seam as given above for the different government townships, the depth at which this coal layer would be reached can be approximately determined. In T. 13 N., R. 4 E., there is a rapid increase in elevation going north and west from the southwest corner of section 10 to the center of section 4, the difference of elevation apparently amounting to 52 feet. In Monitor township, T. 14 N., R. 4 E., the lowest elevation of this seam is represented by a trough which probably trends from the southwestern part of section 21, to the southwest quarter of section 6. The elevation through here is approximately 395 feet A. T. On the west side of the syncline the elevation is some 20 feet higher. The elevation also increases to about 425 feet A. T. in section 11, T. 14 N., R. 4 E., Eastward from here, in the northern portion of T. 14 N., R. 5 E., the elevation changes considerably. The average height, however, is 13 feet lower than the usual elevation, for that portion of the township.

In the shaft hole of the What Cheer mine in the southwestern quarter of section 30, Merritt township, T. 13 N., R. 6 E., the Saginaw coal is from three to four feet thick at a depth of 200 feet, the elevation of the surface being 590 feet above tide. To the eastward, in the north half of section 32, this seam is cut out by heavy beds of sandstone. The main extension of this workable coal basin is northwest or north-northwest, into Saginaw county. In the S. W. ¼ of section 20, T. 14 N., R. 4 E., a recent drill hole into the Saginaw coal gives a thickness of one and one-half feet. The seam here is separated by two feet six inches of gray shale, the lower portion of the seam being one foot thick and 199 feet in depth. The elevation of the surface here is 605 feet above tide.

Middle Rider.

This name has been applied by Mr. Lane to the rider of the Saginaw coal. The average elevation of this seam is 421 feet above tide, or 21 feet above the next lower layer of coal. The extremes of elevation apparently range from 371 to 443 feet A. T., being only slightly less than for the Saginaw seam. In T. 13 N., R. 4 E., the average elevation is 400 feet A. T. In T. 13 N., R. 6 E., 428 feet; in section 12, T. 14 N., R. 3 E., 415 feet A. T.; in T. 14 N., R. 4 E., 423 feet, and in T. 14 N., R. 5 E., 439 feet A. T. If it is desired to obtain the depth of this horizon, the same remarks apply to this coal layer, as to the Saginaw coal.

In the S. W. ¼ of section 23, T. 15 N., R. 3 E., very nearly one mile west of Loehne P. O., the Saginaw coal is replaced by beds of shale which extend down to a depth of 288 feet. If I am right in correlating the Verne coals here, the coal measures show the same downward flexure that is so pronounced in the vicinity of Wolverine No. 3 mine, northeast of Auburn. Thence northward near the line of sections 1 and 2, in the north part of Beaver township, we have heavy beds of sandstone and shale down to a depth of 296 feet, far below the Saginaw coal; neither are the Verne coals represented here, being either washed out or replaced by sandstone beds. In the southwest quarter of section 33, Garfield, the Verne coal is at about the same depth as in the lower portion of the county, showing a pronounced rise from the vicinity of Loehne P. O. The Saginaw coal is not represented in any of the test holes in section 32 and 33, Garfield, there being a heavy bed of gray shale or sandrock at the depth where we would expect this seam to occur. The same remarks hold for section 24 of Garfield and 30 of Fraser, to the northeast. Up to this latitude I have not been able to discover any elevation of the coal measure seams, or the basement formation on which the coal measures rest.

In the southeast quarter of section 10, T. 17 N., R. 5 E., there are the records of three drill holes put down on the land of J. Mansfield, which show a coal horizon at an elevation of 475 to 485 feet A. T.; depth 175-185 feet, and a rider at about 495 feet A. T. The relationship of these two seams to the overlying coal, and additional records of this upper coal, which is relatively in the position of the Verne seam, rather points to the occurrence of the Saginaw coal at this depth and elevation, in this section. It may be, however, that what I have here called the Saginaw coal is really the Upper Verne, as it is about the same elevation above tide as the Upper Verne in the lower part of the county. If this is true, the seams which have been referred to the Verne coals in the northern part of Garfield and Mt. Forest townships, represent a higher horizon than is found near Bay City. Taking into account the general relationship of the coal strata, I believe the correlations will stand as suggested. The greater elevation of the Saginaw coal in the Mansfield holes is probably due to the increase in elevation of the basement formation on which the coal formation rests. This underlying formation comes to the surface in the northeastern part of Arenac county, Omer being near the border line. This increase in elevation of the underlying Grand Rapids formation amounts to some 600 feet between South Bay City and Omer. The Verne seams in the same distance increase at least 150 feet between Bay City and the Rifle river, and probably the greater part of this increase is from a line running west-northwest through Lengsville station. I imagine that the Saginaw and underlying seams gradually feather out as they approach the edge of the basin, each overlying stratum extending farther and farther out as the underlying formation is reached, until the entire Grand Rapids basin became filled up. This original deposition has been modified by the orogenetic movements and perhaps by differential solution below in the Grand Rapids gypsum beds.

Thickness of the Saginaw Coal and Rider.

In the record of four test holes put down in the north half of T. 13 N., R. 4 E., the average thickness of the Saginaw coal is 11 inches; that of its rider 12 inches. In T. 13 N., R. 6 E., the thickness of the respective veins is 9 and 16 inches. In both these townships the rider is more frequently

shown in the bore holes than the Saginaw coal. In the northeast quarter of section 12, T. 14 N., R. 3 E., the Saginaw coal is apparently 5 feet thick in the record of one drill hole, but rapidly decreases in thickness going east. The Middle rider has an average thickness of 13 inches in two test holes in the same quarter section. In Monitor township, T. 14 N., R. 4 E., the Saginaw coal averages 20 inches through, and its rider 9 inches. In T. 14 N., R. 5 E., the relative thickness is 18 and 19 inches. It is thus apparent that the seam which has been designated the Middle rider may prove of workable thickness upon more extensive exploitation.

The character of the foot and roof of the Saginaw coal and Middle Rider is almost invariably of so called fire clay and slate. In Merritt township the roof of the rider is sometimes of sandstone.

10. *Lower Verne.*

This vein of coal has been reached at the mine of the Pittsburg Coal Co. near Amelith, in the shaft of the Michigan Coal & Mining Co. west of Salzburg, and in the entries of Wolverine No. 3 northeast of Auburn. At the Amelith shaft the elevation is very nearly 407 feet A. T. at the mine of the Michigan Coal and Mining Co., 474 feet A. T., at Wolverine No. 3 mine the elevation has again dropped to very nearly 426 feet A. T. In certain places as in the mine of the Michigan Coal and Mining Co., and at Wolverine No. 3 shaft, the Lower and Upper Verne are either directly superimposed upon each other, or are separated by a thin bed of shale or bituminous sandstone. In the shaft near Amelith, there is apparently 47 feet of strata between these two horizons.

The elevation of the Lower Verne in the lower third of Bay county is approximately 440 feet above sea level. The average elevation for several of the government townships is as follows:

T. 13 N., R. 4 E., 432 A. T.; T. 13 N., R. 6 E., 447 A. T.; the northeast part of T. 14 N., R. 3 E., Williams township, 435 A. T.; T. 14 N., R. 4 E., 444 A. T.; T. 14 N., R. 5 E., 451 A. T.; a single record in section 32, T. 15 N., R. 5 E., at 453 A. T.; in section 4, T. 16 N., R. 3 E., a single test hole makes this seam at 512 A. T.; in section 30, T. 16 N., R. 4 E., the Lower Verne is 441 feet, in test hole 462. The approximate depth at which this vein may be found can be determined by ascertaining the elevation of the surface from the contour map, and subtracting the elevations above tide as given above. In prospective developments of this coal vein it will be advisable to have all the coal saved from the drillings and analyzed for iron and sulphur, with the opinion of a competent expert as to the value of the product for commercial purposes. A careful account should also be kept in boring operations for partings of shale or iron carbonate in this coal. The roof of the seam should also receive particular attention from the driller.

In section 15, T. 13 N., R. 4 E., the coal dips toward the center of the section, increasing in elevation southeast and northwest. This increase in elevation continues toward the northwest, until at Bay mine No. 2 the elevation is 450 feet A. T. This upward flexure of the Lower Verne has considerable breadth, as in the records of the Hecla Cement & Coal Co., in section 2, T. 13 N., R. 4 E., the average elevation of this stratum is intermediate between the height of the vein at Amelith and at the shaft house of Bay No. 2 mine in section 4, T. 13 N., R. E. In the central part of Monitor township, T. 14 N., R. 4 E., the elevation of this seam drops to nearly 430

feet A. T., but again increases somewhat in height in the vicinity of Wolverine mine No. 3. The rolls of the Lower Verne and associated strata are brought out in the section G-H. In T. 13 N., R. 6 E., the Lower Verne increases in elevation north and east, the difference in elevation, as far as our records indicate, amounting to 22 feet. In section 30 this coal is found at 428 feet A. T., increasing to 448 feet A. T. in section 19, and then dropping down to 435 feet in section 6, forming a fold not unlike that between the shaft near Amelith, and Wolverine No. 3 mine. Eastward from this western tier of sections this seam has an elevation of about 450 feet A. T. throughout the central part of this township, north and south, as far as our records show.

In the northeast part of Williams this seam is very irregularly deposited if my correlations are correct. It is not impossible that this region is slightly faulted, or other agencies may have operated to produce such irregularities as are given in the test hole records there. A single drill hole in section 17 shows the Lower Verne at 424 feet A. T. or about 10 feet lower than in the eastern part of the township. The elevation here, however, being some 30 feet higher than in the eastern part of the township, this layer is found at a depth of 219 feet, or nearly 40 feet more than in the northeastern part of Williams. Such differences of elevation are to be taken into account in coal development. The Salzburg coal and rider are found at about the normal elevation in section 17.

In T. 14 N., R. 5 E., the Lower Verne shows a tendency to increase in elevation to the northward, with considerable fluctuations in elevation. North from here and along the shore of Saginaw and Tobico bays, this coal horizon is cut out by very considerable beds of sandstone extending as far north as section 13, T. 15 N., R. 4 E.

In the northwest quarter of section 30, Fraser township, T. 16 N., R. 4 E., we again get the Verne coal at 441 feet A. T., or at very nearly the average elevation of this seam in the lower third of the county. Northward from here I believe that the Lower (?) Verne increases rapidly in elevation. Near the southwest corner of section 4, Garfield, this seam may be found at about 512 feet A. T. The test hole records in the southwest part of Garfield apparently do not show this coal horizon.

In places the Lower Verne shows a tendency to split up into two or more layers, separated by thin strata of slate. In section 15, T. 13 N., R. 4 E., we have three layers belonging to this horizon. The average elevation of the different parts of the Lower Verne there is quite nearly 7 feet below the average of that vicinity. Out of 45 test holes in that township 31 have a higher elevation. In section 30, T. 13 N., R. 6 E., the Lower Verne is again separated by shale beds into two parts where this coal horizon has the lowest elevation yet noted in that township. On the other hand in section 20 of Monitor township, T. 14 N., R. 4 E., a split of the Lower Verne is slightly higher than the average for that township, and somewhat less than for the adjacent beds in the same section. In sections 4, 22, and 23 of T. 14 N., R. 5 E., this coal is separated into from two to four beds having about the same elevation as the average of the Lower Verne in this township. In section 4, a sulphur band, probably iron sulphide, is noted as overlying the lower split, and I have based my correlations partly on this information. In places these Lower Verne splits seem to follow the same law of deposition as will be noted for the rider of the Lower Verne; that is a tendency rarely to split up along lower planes of deposition. Whether these splits

are near shore line deposits subject to oscillation and occasional inundations of sediments, with resultant local settling, remains to be seen.

11. *Thickness of the Lower Verne.*

An average of 145 test hole records in which this seam occurs, shows a thickness of a trifle more than two feet. This average would be much reduced by areas in which the coal was never deposited. In addition to this, the coal has been removed over considerable areas by erosion which took place previous to the deposition of the drift or overburden. Inasmuch as the average elevation of this seam is some 440 feet A. T. for the lower half of Bay county, we would not expect much coal inside of the areas approximately shown by the 440 foot rock contour line, on the map which goes with this chapter.

The average of numerous records in the north half of T. 13 N., R. 4 E., is 27 inches; in T. 13 N., R. 6 E., so far as our records indicate anything, of 16 inches; in the northeast part of T. 14 N., R. 3 E., of 30 inches; in T. 14 N., R's. 4 and 5 E., of 30 inches; a single record in T. 15 N., R. 5 E., shows 14 inches of coal; in section 4, T. 16 N., R. 3 E., 26 inches of coal in one test hole; in section 30, T. 16 N., R. 4 E., we have four inches of coal in a drilling there. The Lower Verne varies constantly in thickness, and I have not been able to correlate the depth of this bed with any variation in elevation. Thus we have in section 2 of Frankenlust, three feet of coal at 442, 447, 430 and 422 feet above tide; in section 15 of the same township from three to four feet of coal at 398, 408, 411 and 420 feet A. T. In T. 14 N., R. 4 E., forming part of Monitor township the distribution of the bore holes makes it possible to arrive at a more accurate conclusion concerning the relationship of thickness and elevation. We thus have less than one foot of coal at an average height of 444 feet A. T., from one to two feet at 443 feet A. T., from two to three feet at 450 feet A. T., from three to four feet at 446 feet A. T., and from four to five feet at 443 feet above sea level. These deductions might be modified slightly by taking smaller units of areas. It will also be observed in the cross section G-H that the coal was laid down more or less regardless of local irregularities in the underlying strata, somewhat in conformity with Kuntze's idea of the formation of coal, with the exception of numerous local irregularities of the coal strata.

12. *Character of the Foot and Roof of the Lower Verne.*

In the records of 126 test holes showing the foot of this coal seam, 10 holes had a sandstone bottom, that of the remainder being of fire clay or shale. The roof is very generally of slate, or more properly shale, the drillings only showing seven test holes with a sandstone top out of 145 drill records. These facts as near as they can be determined from our records, serve to show the close relationship existing between shale beds and that of this coal layer, as far as its immediate deposition is concerned. Two of our drill records have a sulphur roof as in section 12, T. 14 N., R. 4 E., and in section 4, T. 14 N., R. 5 E. It is to be regretted that we have no specimens of this. Occasionally, as at the Amelith mine, the roof is a bituminous limestone. The roof also very commonly shows a slickensided shaly structure with an irregular fracture, quite unlike the even bedded slaty shale over the Upper Verne. There is considerable variation in the structure of the roof, which is not clearly brought out in the drill records.

Upper Verne.

Parting.

Lower Verne.

AIR COAL CUTTING MACHINE, WENONA MINE.

The fossil contents of the roof, together with its physical structure, render it a comparatively easy matter to separate the Upper and Lower Verne. In the roof of the Lower Verne, some of the most common forms which do not occur in the slate over the Upper Verne are: *Chonetes flemengi, Productus prattenanus, Productus muricatus*, and *Orthoceras rushense*. The first three species have a broad straight hinge line which forms the top, with a rather square form, the sides of the shell meeting the hinge line at right angles, which are more rounded at the bottom. This is quite unlike the species found in the shale over the Upper Verne, which is long and oval shaped at both ends, being not unlike the tongue of a bird. This is *Lingula mytiloides*. I believe that it would be well for drillers to keep samples of the roofs over the different coal seams for purposes of identification of the underlying seam. It is the duty of the Geological Survey to aid in such identifications. We have already mentioned the value of keeping samples of the different coal strata.

13. *Lower Verne Rider.*

In the territory leased by the Pittsburg Coal Co. near Amelith, and in section 33, T. 14 N., R. 4 E., this is a layer of coal which occupies a considerable depression of the Lower Verne, the Upper Verne keeping at much the same elevation as at the shaft house of Bay mine No. 2, in the S. E. ¼ of section 4, T. 13 N., R. 4 E. In section 15, T. 13 N., R. 4 E., this rider is from six to 25 feet above the Lower Verne, the greatest difference of thickness being above the lowest depth of the Lower Verne. We thus have the rider at 423 feet A. T. where the coal bed below is at 398 feet A. T.; near the southwest corner of section 10, the relative elevations are 427 and 437 feet A. T. The tendency was constantly to fill up, and consequently even out by the strata deposited the hollows in the coal basin in this particular district. In section 33, T. 14 N., R. 4 E., this rider is 11 feet above the Lower Verne.

14. *Upper Verne Coal.*

This coal has had a greater economic development than that of any other seam in Bay county and sustains to the commerce of this portion of Michigan, the same relation as does the Saginaw coal to St. Charles and the environs of Saginaw. As has already been observed, the elevation of this seam is 475 feet above sea level near the shaft of the Pittsburg Coal Co. near Amelith. In other localities where I have been able to obtain precise information from entries dug into this coal, the elevation is as follows, using the same datum, which is the mean tidal elevation of New York bay: At the shaft of the Michigan Coal and Mining Co., section 25, T. 14 N., R. 4 E., 487 A. T.; at the Old Central Mine, in section 25, T. 14 N., R. 4 E., 476 A. T.; at Bay No. 1 shaft, now abandoned, in section 33, T. 14 N., R. 4 E., 467 A. T.; Bay No. 2 mine, section 4, T. 13 N., R. 4 E., 463 A. T.; the Old Monitor Mine, also abandoned, in section 28, T. 14 N., R. 4 E., 465 feet A. T.; at Wolverine No. 1, which is worked out, in section 4, T. 14 N., R. 5 E., 470 A. T.; Wolverine No. 2, section 17, T. 14 N., R. 4 E., 461 A. T.; near Wolverine No. 3, in section 12, T. 14 N., R. 3 E., nearly 430 feet A. T.; at the shaft of the Hecla Portland Cement Co., in section 2, T. 13 N., R. 4 E., 471 feet A. T.; the Wenona mine in section 4, T. 14 N., R. 5 E., 460 feet A. T.; the Valley mine, section 1, T. 13 N., R. 4 E., 466 feet A. T. It will thus be observed that the elevation of this coal horizon is generally from 460 to 470 A. T. In the correlations of the test holes which are given at the end of this chapter I have used these shaft records as geological bench marks

from which to determine the position of this and associated coal beds in the lower portion of the county.

The average elevation above sea level of the Upper Verne is 463 feet. This is from the records of 203 test holes, the greater part being in the lower third of the county. In T. 13 N., R. 4 E., the average of 61 drill holes is 461 feet A. T.; in T. 13 N., R. 5 E., of three drill holes is 459 A. T.; in T. 13 N., R. 6 E., of 463 feet A. T.; in the northeast part of T. 14 N., R. 3 E., the average of three drillings gives 440 feet; in T. 14 N., R. 4 E., we have from 99 records an average elevation of 464 feet or only slightly more than in Frankenlust township to the south of it; in T. 14 N., R. 5 E., 29 records gives an average height of 457 feet; in T. 15 N., R. 3 E., we have only one drill hole which makes this seam at 440 feet A. T.; in T. 16 N., R. 3 E., four test holes make the Upper Verne 495 feet A. T., and T. 17 N., R. 3 E., three records give an average of 519 feet A. T. In certain drill records where the Upper Verne occurs more than once, I have had to use the number of splits, or sub-divisions of the Upper Verne, instead of the single drill records in making a correct average determination. The manner in which these records are distributed makes these averages more or less local for each township, and therefore less representative than if they were less bunched together.

Comparing the different townships in the lower third of the county we find that the Upper Verne has much the same average elevation east and west in T. 13 N., as far as represented by our records. Thence going north from T. 13 N., R. 4 E., we find a slight increase in elevation in T. 14 N., R. 4 E., with a slight general dip to the east and a very considerable falling off at the northwest. This easterly dip is also apparent in the tier of sections to the south. Going northwest and north from Monitor township to the east central part of Beaver the Upper Verne has quite a pronounced sag, being some 440 feet A. T. as far as shown by our records. In the south and east part of Garfield this coal is again back to about its normal elevation, increasing rapidly in height in section 4 of this township. In section 10 of Mt. Forest, the increase northward is less noticeable.

Within the limits of the different government townships this seam in T. 13 N., R. 4 E., varies from 432 to 491 feet A. T., as in sections 15 and 2 respectively. The dip here conforms to a somewhat more pronounced sag in the underlying Lower Verne. In T. 13 N., R. 5 E., we have the records of three drill holes in sections 6 and 7, where the Upper Verne is from 458 to 460 feet A. T. In T. 13 N., R. 6 E., half a dozen records in sections 3, 6, 23 and 30 show this layer from 460 to 470 feet above tide, as in sections 6 and 23 respectively. In Williams, T. 14 N., R. 3 E., I have only been able to satisfactorily identify this seam in section 12 and possibly in 24. The elevation is from 430 to 451 feet A. T., increasing to the westward. This quite pronounced sag in section 12 is also noticeable in the adjoining sections 6 and 7, Monitor township. The two Verne coals are only separated by thin seams of slate in section 12. In T. 14 N., R. 4 E., of Monitor township, outside of sections 6 and 7, the elevation varies from 451 A. T. as in sections 16 and 19 to 489 feet in section 25 and 487 feet in section 17. Throughout the central part of Monitor the height is quite persistent at from 460 to 470 feet A. T. In T. 14 N., R. 5 E., the variation in elevation is from 456 feet in the northeast quarter of the northwest quarter of section 4 to 487 A. T. in section 25, and 484 feet in sections 12 and at Salzburg. Locally the coal dips quite irregularly. In order to obtain the

approximate depth of this seam, the elevations as given above may be subtracted from the ground level as given by the surface contour map.

In section 2 of Frankenlust township I believe that the Upper Verne is split into two and three seams in two drill holes in that locality. Likewise in section 19 of Monitor we apparently have the same thing taking place under apparently normal conditions of formation. In section 4, T. 14 N., R. 5 E., the Upper Verne is separated by a thin band of black shale into two beds of workable thickness which are relatively quite depressed. The same tendency to split was noted for the Lower Verne, with such explanation as I was able to give.

By taking into account the approximate elevation of the rock contours and the depth of this seam, the area in which this coal has been eroded away can be determined; that is the general average of the Upper Verne being some 460 feet A. T., we would not expect to find this seam inside of the 460 foot rock contour line, on account of the erosion of the bed rock.

15. *Thickness of the Upper Verne.*

In the records of 203 test holes showing the occurrence of this bed, the average thickness is very nearly 29 inches. This is not a true average, however, as there are 259 drill holes in about the same territory in which this seam does not occur. Taking into account the entire number of holes that have been drilled, we have a more approximate thickness of 12 inches for the lower third of the county. Our first estimate is too large on account of the way in which the records have been bunched around favorable deposits, and this will of course affect the second result. This estimate will in turn be reduced by the area in which this coal has been entirely washed away. The area embraced in this estimate of 12 inches covers 136 3-10 square miles. The entire area of Bay county is approximately 450 square miles. Assuming the average to be the same throughout, we have a total of 504,576,000 tons of coal. This is assuming that one acre of coal one foot thick contains 1,752 tons.

For the different townships the following averages were obtained: T. 13 N., R. 4 E., 24 inches; T. 13 N., R. 6 E., 19 inches; T. 14 N., R. 4 E., 32 inches; T. 14 N., R. 5 E., 31 inches. In the remaining townships there are scarcely sufficient records to form an estimate of any value.

16. *Character of the Foot and Roof of the Upper Verne.*

In T. 13 N., R. 4 E., where this coal has been developed, the stratum underlying this coal is commonly of fire clay or shale, only four holes showing a sandstone bottom. This may be important in future development, as the fire clay or shale has been shown to be adapted to the manufacture of brick, tiling, and as a component in the production of Portland cement. The roof of this coal is commonly a black even bedded "slate" or more properly shale. There is one place in section 15 with a sandstone roof. In still another place in the same section, the overlying strata have been eroded away, leaving a covering of the unconsolidated drift. I have also been in one mine where an entry terminated in a drift-filled channel filled with gravel. In T. 13 N., R. 5 E., three test holes in sections 6 and 7 have a slate roof; one hole has a fire clay foot. In T. 13 N., R. 6 E., out of six drill holes, only one has a sandstone roof and that is the one with the highest relative elevation. A point worth investigating is whether shale beds some-

times run out, being replaced by sandstone under certain circumstances. Also in this same township the foot is of shale or slate except in a hole with a sandstone roof which has a similar bottom.

In T. 14 N., R. 4 E., the foot is commonly a fire clay or shale, there being only four bottoms of sandstone out of 90 records. The records of seven holes out of 98 show a sandstone roof, the remainder being of slate or shale. Two of these records in section 33 show this sandstone roof below the normal level and overlying a workable deposit of coal. Again in section 16, two drill holes have a sandstone cover near the lowest level of this seam; in one place the coal being two inches thick, in another 4 feet 10 inches. In section 19 we have a sandstone roof over almost four feet of coal at its highest elevation in that section, as far as determined. Obviously the formation of sandstone beds under such circumstances is very irregular, as we should naturally expect, being shore line deposits.

In T. 14 N., R. 5 E., the foot of this coal is sandstone in four records out of 26. The roof is of slate or shale in 26 records; three others are said to have a limestone roof. In T. 15 N., R. 3 E., we have the record of a single test hole in section 23 which has both a foot and roof of shale rock. In T. 16 N., R. 3 E., the records of three test holes show a foot and roof composed of shale or slate. Similar information was obtained from three drill holes in sections 10 and 33, T. 17 N., R. 3 E.

General remarks have already been made concerning the character of this roof in connection with this subject on the roof of the Lower Verne. During the summer of 1904 Mr. Geo. Bradford and I ascertained the occurrence of the Lingula black shale over a split of the Upper Verne coal at the shaft of the United City Coal Mine in West Bay City. This split was one foot thick and is underlain by three feet of gray shale, which in turn covers about four feet of coal, probably of Upper Verne age. In this gray shale David White of the U. S. Geological Survey has obligingly identified the following species:

WASHINGTON, D. C., JANUARY 24, 1905.

(1) Mariopteris muricata.
(2) Pseudopecopteris cf. avoldensis, Stur. sp.
(3) Sphenopteris (Crossotheca) n. sp.
(4) Sphenopteris (Palmatopteris?) sp., indeterminable fragment.
(5) Heterangium? stem fragment.
(6) Pecopteris dentata? (obscure).
(7) Neuropteris rarinervis (var.).
(8) Calamites ramosus.
(9) Sphenophyllum emarginatum.
(10) Bothrodendron cf. minutifolium.
(11) Lepidodendron aculeatum.
(12) Stigmaria verrucosa.
(13) Cordaites sp.
(14) Lingula carbonaria Shum.

From the composition of this flora, I conclude that it is very likely of Mercer age, and certainly not older, though possibly it may have come from an horizon as high as the Clarion group.

Thanking you for your kind interest in inducing Mr. Bradford to send me this very interesting material which I have been very glad to examine, I remain, Very truly yours,

(Signed) DAVID WHITE.

17. *The Verne Coals in Garfield and Mt. Forest Townships.*

In the remarks made relative to the Saginaw coal, it was found necessary to make comparisons with the Verne beds in this portion of Bay county. In the four drill records furnished by Wampler in sections 32 and 33 Garfield township, the Verne coals are either washed out or are replaced by heavy beds of sandstone, with the exception of one hole in section 33, where the Upper Verne may be represented at about the same elevation above tide as in the lower third of the county, but at considerably greater depth on account of the increased elevation of the surface there. Also in two drill holes in section 24, Garfield, we have the Upper Verne and the Upper rider represented in much the same relationship as farther south. Evidently we have not yet come to the upward dip of these seams, a counterpart of which, is furnished in the increased elevation of these beds south of St. Charles. In section 30 of Fraser, T. 16 N., R. 4 E., we probably have the Lower Verne at about 441 feet above tide, or almost precisely at the same elevation as in the lower part of the county. Drilling operations through here could be carried on much the same as farther south, making due allowance for the difference of surface elevation. Northward, however, I believe that the beds begin to rise, until, in the region of the Rifle river we probably have the Verne coals some 150 or 175 feet higher than in the southern portion of Garfield township.

Near the southwest corner of section 4, Garfield, T. 16 N., R. 3 E., Mr. F. J. Tromble passed through a bed of coal at an elevation of 512 feet A. T., which I have provisionally correlated with the Lower Verne. This coal bed is also struck at an elevation of 513 feet A. T. in sections 33 and 34, T. 17 N., R. 3 E. What may be in the position of the Upper Verne was also obtained by Mr. Tromble at an elevation of 10 feet above the bed in the bore hole already referred to, in which he obtained 3½ feet of coal separated by two inches of slate toward the bottom. This bed is approximately 522 feet A. T. here. To the north, and on the land of Jas. Mansfield in the S. E. ¼ of section 10, T. 17 N., R. 3 E., I believe that this same seam occurs at an elevation of 526 feet A. T. At Estey Mr. W. E. Calkins, the driller, obtained 1½ feet of coal at a depth of 183 feet, and approximately 530 feet above sea level, which may also belong to the same Verne horizon. Apparently this bed is quite persistent in elevation within the limits under discussion, but it will also be necessary to refer to the contour map for differences in depths, which are due to inequalities in the surface elevation, in case of development. Thus we have this bed at a depth of 134 feet on the Mansfield property, and at 183 feet below the surface at Estey, but with a coal bed at very nearly the same elevation above sea level. Reference has already been made to the apparently increased elevation of Verne coals in this vicinity. If these correlations are borne out by future development, it will probably be determined that the basement on which the coal formation rests, rises in this direction.

18. *Upper Rider.*

The rider of the Upper Verne is found at an average elevation of 482 feet A. T., or approximately 100 feet lower than the level of Saginaw bay. This is from the records of 135 drill holes, a greater part being from the lower third of the county. The average elevation of the Upper rider is 19 feet above that of the Upper Verne. However, in 77 records where the Upper Verne is actually associated with this rider, as in the lower third of this county, the rider is 25 feet higher. On the average we find the Upper Verne

at a relatively lower elevation where this rider is deposited above it. Thus in T. 13 N., R. 4 E., the Upper Verne is 461 feet A. T., taking into account all the holes in which that seam occurs there, but in the 47 holes in which the Upper Verne and Upper rider occur together the Upper Verne is only 455 feet A. T., the difference in the elevation of six feet conforming with the general average given above, where the Upper Verne is directly compared with the Upper rider in all drill holes where the two strata are represented.

The same fact is brought out in 58 records in T. 14 N., R. 4 E. Where the Upper Verne is associated with the Upper rider there, the average elevation above tide of the former is 461 feet. The general average of the Upper Verne for that township is 464 feet A. T. Carrying the comparison still further, we find that where the Upper Verne is alone represented in the test holes, it is at the average height of 472 feet A. T., or only nine feet lower than the average elevation of the Upper rider. It is apparent from these three classes of records, that the Upper Verne, at least in this township, shows a constantly decreasing elevation, according to the absence or presence of the Upper rider. This factor will be of some use to coal drillers and operators in determining the distribution of the different beds of coal.

In T. 14 N., R. 5 E., we have 10 drill holes in which the Upper Verne and Upper rider were deposited together, the elevation of the former being 445 feet A. T. The average elevation of the Upper Verne is 457 feet A. T., which of course includes all records in which this seam was laid down both with and without the Upper rider.

Mr. Lane in his chapter on the "Occurrence of Coal" states[6]: "In the lower and thicker parts these troughs of coal are likely to be capped by a smaller coal seam known as a rider." This mode of occurrence was stated somewhat tentatively, but as we have just seen it is abundantly supported by data in our possession. Bain in his report on Iowa coal,[7] gives a theoretical explanation of this by supposing that the shrinkage and contraction of the lower coal beds in slowly settling and compacting, made a basin in which the upper coal was formed. At the same time I am unable to correlate the relatively lower elevations and greater thicknesses of beds which would follow as a natural corollary. It may be that during the period preceding the formation of the Upper Verne seam, that the beds of shale and sandstone formed local pools of deposits in which the Upper Verne was deposited, these relatively lower areas existing during the formation of the Upper rider, but showing in the interim a constant tendency to become filled up with beds of shale and sandstone between these two coal seams. In these local areas, perhaps forming local bays and estuaries, beds of coal are formed in a manner suggested by Kuntze, only somewhat more localized. The manner in which the Bay county coal areas show local filling and evening off of inequalities, due to the formation of shale and sandstone beds, at least suggests something of this nature. On the other hand, I believe that the beds of vegetation were laid down and compacted more or less regardless of the elevation and character of the underlying strata, forming originally water logged mattresses of vegetation. Judging from present conditions it is a common observation that marine or lacustrine vegetation is more abundant near the shore line than in deeper water. If it is possible to imagine beds of coal being formed under such circumstances during carboniferous times, we should actually have greater deposits of coal at higher elevations near the shore line. Into these relatively lower areas other beds would be laid down

[6] *Volume VIII*, Part 2, p. 32. 1902.
[7] *1897, p. 229–300; Journal of Geology III*, p. 646.

after coal formation had for the time being ceased. After these areas have become measurably filled up such a rider would be laid down in the shallow surface waters, in a manner identical with that of the Upper Verne and the Upper rider. This fact was also brought out for the Lower Verne and the Lower rider in T. 13 N., R. 4 E. Altogether I think that sedimentation and environment were the more important governing factors in producing workable beds of coal, and that of the overlying riders. It is undoubtedly true, however, that different conditions prevailed during the formation of the coal deposits in different portions of the eastern United States.

As stated at the beginning of this section, the average elevation of the Upper rider is 482 feet A. T. In T. 13 N., R. 4 E., the height is 481; in six holes in T. 13 N., R. 5 E., of 489 feet; in three holes in T. 13 N., R. 6 E., of 484 A. T.; in five holes in the northeast part of Williams, T. 14 N., R. 3 E., 475 feet A. T.; in 58 drill holes in T. 14 N., R. 4 E., 481 feet A. T.; in 10 records in T. 14 N., R. 5 E., 483 feet A. T.; from four records in T. 15 N., R. 4 E., 488 feet A. T.; from four records in T. 15 N., R. 5 E., 488 feet A. T.; in one hole in T. 15 N., R. 5 E., 493 feet A. T.; one record in T. 16 N., R. 3 E., 480 feet A. T. While the Upper rider shows an extreme average range of elevation of about 18 feet, that of the Upper Verne amounts to some 79 feet, showing the same general tendency to fill up and equalize inequalities in elevations, as has been noted for lesser areas of the coal formation.

Occasionally, as in the records of the property leased by the Hecla Portland Cement and Coal Co. in the northeastern part of Frankenlust township, as well as in Monitor township, the Upper rider shows one or two splits, which apparently occupy but limited areas. Taken as a unit, these riders have a lower relative height than the main rider of the Upper Verne, and at least occasionally, were deposited in local swales of the Upper Verne coal. Such depressions, however, do not always contain more than one rider.

19. *Thickness of the Upper Rider.*

Throughout its extent in the southern part of Bay county, the average thickness of this seam in 135 holes where this bed has been struck, averages 16 inches. Taking into account, however, the 327 holes in which this seam is not represented, in approximately the same territory, the average is reduced to about five inches. Also, inasmuch as this seam is not represented inside the 480 foot rock contour line, as near as we have been able to locate the same, the average would still be further reduced. Providing, however, that this seam proves to be of suitable quality, the time will probably come when workable deposits will be utilized in certain localities. The following table will show the thickness of this bed in the different townships, and the number of holes.

Township.	Thickness.	No. of holes.
T. 13 N., R. 4 E.	16 inches.	47
T. 13 N., R. 5 E.	12 inches.	6
T. 13 N., R. 6 E.	8 inches.	3
T. 14 N., R. 3 E.	19 inches.	5
T. 14 N., R. 4 E.	17 inches.	58
T. 14 N., R. 5 E.	20 inches.	10
T. 15 N., R. 4 E.	3 inches.	4
T. 15 N., R. 5 E.	7 inches.	1
T. 16 N., R. 3 E.	6 inches.	1

In T. 13 N., R. 4 E., if I am correct in my correlations, we have two feet six inches of this coal in the N. E. ¼ of section 2; in section 15 the coal is sometimes of workable thickness where this property has been developed by the Pittsburg Coal Co., in section 15. In T. 13 N., R. 5 E., the few records that we have show from four inches to one foot eight inches of coal. In T. 14 N., R. 3 E., we have anywhere from three inches of coal, as in the N. E. ¼ of section 12, to 3½ feet in the N. E. ¼ of section 13. At both these places this horizon is at about the same elevation. In T. 14 N., R. 4 E., the Upper rider is over three feet thick in the west central part of the township in the southeast ¼ of sections 17, 18 and 19. In section 19 the elevation is 470 feet A. T., in sections 17 and 18, close to 485 feet, or more than four feet above the average elevation of the Upper rider in this township. In the S. W. ¼ of section 7 there is apparently over four feet of coal referable to this horizon at an elevation of 470 feet A. T. There are 11 holes in this township containing over two feet of coal at various elevations ranging from 467 to 499 feet A. T. In T. 14 N., R. 5 E., the Upper rider varies from 470 to 489 feet A. T. with the exception of one record in the southeast quarter of section 17. In section 4 we apparently have from four to six feet of coal at an elevation of 482 feet A. T. which is very nearly the average elevation of this seam in this township. In sections 30, 17, and 33 we have less than one foot of coal at elevations varying from 470 to 489 feet A. T. The meagerness of our records in the western part of the county do not permit of any results being drawn.

20. *Character of the Foot and Roof of the Upper Rider.*

In T. 13 N., R. 4 E., out of 47 drill holes showing this coal, the foot of all is composed of fire clay or shale. In two drill holes we have this seam overlain by drift sand, as in sections 2 and 5; in three records in section 15, and at another hole in section 1 this coal is under a bed of hardpan. Also in section 15 there is a sandstone roof. These records will serve to illustrate the caution which must be used in case this seam is ever developed. It is not uncommon to find a bed of sand or gravel overlying the bed rock which is quite abundantly water bearing.

In T. 13 N., R. 5 E., we have out of six records, one drill hole with a sandstone foot and one under a clay or hardpan roof. In T. 13 N., R. 6 E., there are two places in section 3 with a sandstone bottom; the roof in all three records is of slate. In T. 14 N., R. 3 E., the character of the foot and roof is of shale and slate in the five drillings we have from there.

From Monitor township where this seam occurs in 58 drill records, there is only one place, as in section 36, where the foot is composed of sandstone, the remainder being of fire clay or shale. In section 16 the roof is of sandrock in two localities as well as at one place in sections 33 and 36. In section 19 we have this coal under a bed of gravel.

In T. 14 N., R. 5 E., there are 10 records which have a foot and roof composed of shale or so-called "slate." The same remarks hold for the four records in T. 15 N., R. 4 E., In the single record which we have in T. 15 N., R. 5 E., showing this seam both the foot and roof is of sandstone.

21. *The Salzburg Coal and Rider.*

This coal and its rider have frequently been removed by erosion; while in other localities these seams have not been deposited where the bed rock is *sufficiently* high to contain this horizon. This coal bed as represented in 80

drill holes, has an average elevation of 494 feet A. T. or approximately 12 feet above the average elevation of the Upper rider. The average thickness of this seam is two feet, which indicates a very well developed deposit in certain places. The thickness, elevation above tide, and the number of holes in which this seam has been identified in the different townships, is shown in the following table:

Township.	Thickness.	Elevation A. T.	No. of holes.
T. 13 N., R. 4 E.....	23 inches.	496	10
T. 13 N., R. 5 E.....	18 inches.	495	3
T. 13 N., R. 6 E.....	9 inches.	489	2
T. 14 N., R. 3 E.....	16 inches.	504	5
T. 14 N., R. 4 E.....	26 inches.	501	36
T. 14 N., R. 5 E.....	30 inches.	493	15
T. 15 N., R. 4 E.....	7 inches.	497	7
T. 15 N., R. 5 E.....	10 inches.	497	1
T. 16 N., R. 4 E.....	30 inches.	502	1

In T. 13 N., R. 4 E., this bed varies from eight inches thick as in section 2, to four feet eight inches in section 7, the elevations above tide being 505 and 493 feet respectively. Apparently this coal is thick enough to work in section 12. The variations in height run from 491 feet in section 1 to 505 feet A. T. in section 2. The roof is of shale with the exception of one hole in section 1 where the overlying bed rock has been washed away leaving the coal under a bed of hardpan. In one hole in section 12 the foot is sandstone overlain by three feet four inches of coal.

In T. 14 N., R. 3 E., the Salzburg coal is from six inches thick, height 508 feet A. T., section 6, to two feet eight inches in section 17, 503 feet A. T. The roof is of shale or slate, with the exception of a hole in section 12 under a bed of sand or gravel.

In T. 14 N., R. 4 E., comprising the greater part of Monitor township, we have 36 records showing this seam in sections 6, 7, 12, 13, 16-21, 33, 36. The thickness varies very considerably. In section 36 we have a bed two inches thick with a foot and roof of sandstone, elevation 499 feet A. T. In this same section there is almost 3 feet of coal overlain by and underlaid with shale at 504 and 508 feet A. T. In section 19 we have again 3 inches of coal at 491 feet A. T., while near by we have two feet eight inches at 504 feet A. T. In section 17, this bed varies from three inches to two feet three inches at 501 to 514 feet respectively A. T. In sections 16, 21, 20, 13, 6 and 18 this coal is over three feet thick in places. At two localities in section 18 there is six and seven feet of coal represented in our records, with a slate roof, which show the greatest development of this bed. The beds are at 507 and 496 feet A. T. respectively. The roof of this coal is quite generally of slate or shale. However, in section 36, this is composed of sandstone in one record there, with an equal number in sections 20 and 21. In section 17 we have hardpan overlying this coal; in sections 17 and 21 there are two records with beds of sand and gravel on top. In section 7 we have a clay bed deposited on this coal. The foot of this coal is of so-called fire clay or shale in all our 36 records, with the exception of two in sections 16 and 36 formed of sandstone.

In T. 14 N., R. 5 E., section 29, we have from six inches to four feet nine inches of coal at very nearly 500 feet A. T. In sections 29, 30, and 31 this bed of coal is occasionally from three feet to four feet nine inches thick in

places, with a roof of slate or shale. In section 29 this coal is overlain by hardpan; otherwise the roof so far as explored is of shale. The foot in all our 15 holes is of fire clay or shale.

In T. 15 N., R. 4 and 5 E., the Salzburg coal occurs in sections 24 and 19, at an elevation of from 494 to 507 feet above sea level respectively, the average height being 500 feet A. T. The thickness varies from two to 13 inches. The foot and roof are of slate or shale, with the bed rock at about 520 feet A. T. In section 30, T. 16 N., R. 4 E., there is 30 inches of coal at about this horizon.

The Salzburg rider is found at about 515 feet A. T.; average thickness 10 inches. In the vicinity of the Valley and Hecla mines the rider is not shown, and at least in places, has not been deposited. Also in the vicinity of Wolverine No. 2 mine and in sections 16 and 17 of Monitor we get it again.

The Salzburg coal will in general only be found inside the 500 foot rock contour line, as nearly as I have been able to locate the same, and without making any allowance for ups and downs of elevation. If this coal is developed, care would have to be used that a water bearing gravel which is frequently laid down on the bed rock, is not tapped from the wrong side.

While it is not assumed that the subjects which have been discussed in this chapter will not be modified by future developments; it is believed, nevertheless, that the information given may be of use in guiding and promoting future operations. Particular attention is called to the records, cross sections and map which accompany this portion of the volume. Additional information concerning the thickness and structure of the drift or overburden, important in sinking shafts, can be obtained in chapter 4 on soils and sub-soils. Also in the chapter on economic geology will be found the records of several wells arranged by sections in alphabetical order by townships, which will help to give the distance to rock.

22. *Drill Hole Records for Coal in Bay County.*

Records of Amelith Coal Territory.

Test Holes No's 1-40.

TEST HOLE NO. 1.

In the S. W. ¼ of the S. E. ¼ of section 15, T. 13 N., R. 4 E., the elevation above tide is 600.′

Clay	90′		90′		
Hardpan	16′		106′		
Light slate	3′		109′		
Slate	39′	2″	148′	2″	
Sand rock	6′		154′	2″	
Fire clay and slate	21′		175′	2″	
Coal, Lower Verne	4′	5″	179′	7″	at 420 A. T.
Light slate	11′		190′	7″	
Black slate	5′		195′	7″	
Fire clay	1′		196′	7″	

TEST HOLE NO. 2.

In the S. W. ¼ of the S. E. ¼ of section 15, T. 13 N., R. 4 E., the elevation above tide is 601.′

Clay	90′	90′	
Sand and gravel	2′	92′	
Clay	24′	116′	
Sand	4′	120′	
Slate	5′	125′	
Bad top	....	....	

Coal, Upper Rider	2′	6″	127′	6″	at 474 A. T.
Fire clay	4′	6″	132′		
Slate	53′		185′		
Black slate	0′	3″	185′	3″	
Fire clay	5′	3′	190′	6″	
Sand rock	6′	3″	196′	9″	
Slate	33′		229′	9″	
Coal, Middle Rider	0′	4″	230′	1″	at 371 A. T.

TEST HOLE NO. 3.

In the N. E. ¼ of the S. W. ¼ of section 15, T. 13 N., R. 4 E., the elevation above tide is 603.′

Clay	80′		80′		
Sand	8′		88′		
Clay	34′		122′		
Black slate	5′		127′		
Fire clay	3′		130′		
Black slate	37′	2″	167′	2″	
Fire clay	2′	6″	169′	8″	
Black slate	7′	1″	176′	9″	
Coal		3″	177′		at 426 A. T.
Fire clay	5′		182′		
Coal, Lower Verne		5″	182′	5″	at 421 A. T.
Black slate	4′		186′	5″	
Fire clay and slate	13′		199′	5″	
Light slate	24′		223′	5″	
Black slate	2′	8″	226′	1″	
Fire clay and slate	3′	5″	229′	6″	

TEST HOLE NO. 4.

In the N. E. ¼ of the S. W. ¼ of section 15, T. 13 N., R. 4 E., the elevation above tide is 603.′

Clay	95′		95′		
Sand	13′		108′		
Gravel	3′		111′		
Clay	12′		123′		
Black slate	1′		124′		
Coal, Upper Rider	3′	9″	127′	9″	at 475 A. T.
Fire clay	3′		130′	9″	
Sand rock	8′		138′	9″	
Light slate	21′		159′	9″	
Dark slate	16′		175′	9″	
Fire clay	5′		180′	9″	
Light slate	4′		184′	9″	
Fire clay	1′		185′	9″	
Black slate	8′	4″	194′	1″	
Coal, Lower Verne	2′	3″	196′	4″	at 407 A. T.
Fire Clay	11′	5″	207′	9″	

TEST HOLE NO. 5.

Hole near shaft in the N. W. ¼ of the S. E. ¼ of section 15, T. 13 N., R. 4 E., the elevation above tide is 601.′

Clay	146′		146′		
Sandy clay	2′		148′		
Black slate	20′		168′		
Fire clay	4′		172′		
Gray shale	2′		174′		
Sand rock	3′		177′		
Fire clay and sand rock	12′		189′		
Coal, Lower Verne	2′	5″	191′	5″	at 410 A. T.
Black slate		8″	192′	1″	
Fire clay	5′	6″	197′	7″	

TEST HOLE NO. 6.

Near shaft, in the N. W. ¼ of the S. E. ¼ of section 15, T. 13 N., R. 4. E., the elevation above tide is 601.′

Clay	145′		145′		
Slate	36′	4″	181′	4″	
Coal, Lower Verne	2′	8″	184′		at 417 A. T.

TEST HOLE NO. 7.

In the S. W. ¼ of the N. E. ¼ of section 15, T. 13 N., R. 4 E., elevation above tide is 605.′

Clay	104′		104′		
Slate	43′		147′		
Coal, Upper Verne	3′	7″	150′	7″	at 455 A. T.
Fire clay	13′		163′	7″	
Slate	23′	7″	187′	2″	
Coal, Lower Verne	1′	6″	188′	8″	at 416 A. T.

TEST HOLE NO. 8.

At the west quarter post of section 15, T. 13 N., R. 4 E, elevation above tide is 602.′

Clay to	105′		105′		
Sand	7′		112′		
Slate	22′		134′		
Sandrock	4′		138′		
Slate	15′		153′		
Sandrock	6′		159′		
Slate rock	8′		167′		
Fire clay	4′		171′		
Slate	5′	10″	176′	10″	
Coal, Lower Verne?	2′	10″	179′	8″	at 422 A. T.

TEST HOLE NO. 9.

In the S. E. ¼ of the N. W. ¼ (?) of section 15, T. 13 N., R. 4 E., elevation 602′ A. T.

Clay	85′		85′		
Sand	61′		146′		
Slate	6′		152′		
Fire clay	4′		156′		
Slate	14′		170′		
Coal, Upper Verne		5″	170′	5″	at 432 A. T.
Fire clay	9′	7″	180′		
Slate	19′		199′		

TEST HOLE NO. 10.

In the N. W. ¼ of the S. E. ¼ of section 15, T. 13 N., R. 4 E., elevation above tide is 599.′

Clay	118′		118′		
Slate (drift's specimen)	1′		119′		
Sand	3′		122′		
Poor coal, Upper Rider	2′		124′		at 475 A. T.
Light slate	9′		133′		
Black slate, horizon of Upper Verne	20′	8″	153′	8″	
Fire clay	5′		158′	8″	
Light slate	5′		163′	8″	
Fire clay	4′	4″	168′		
Gray rock	13′		181′		
Fire clay	2′		183′		
Sandrock	16′		199′		
Light slate	3′		202′		
Gray rock	15′	5″	217′	5″	

TEST HOLE NO. 11.

In the N. W. ¼ of the S. E. ¼ of section 15, T. 13 N., R. 4 E., the elevation above tide is 599.′

Clay	74′		74′		
Hardpan	10′		84′		
Sand	3′		87′		
Clay	49′	5″	136′	5″	
Sand	2′		138′	5″	
Slate	3′	11″	142′	4″	
Coal, Upper Verne		9″	143′	1″	at 459 A. T.
Fire clay	1′	5″	144′	6″	
Slate	49′		193′	6″	
Coal, Lower Verne	2′	6″	196′		at 403 A. T.
Fire clay and slate	3′		199′		
Sandrock	8′		207′		

TEST HOLE NO. 12.

In the N. W. ¼ of the S. E. ¼ of section 15, T. 13 N., R. 4 E., elevation above tide is 600.′

Clay	90′		90′		
Sand	10′		100′		
Clay	12′		112′		
Sand	1′		113′		
Black slate	6′		119′		
Coal, Upper Rider	4′	6″	123′	6″	at 477 A. T.
Gray shale	18′		141′	6″	
Coal, Upper Verne		6″	142′		at 458 A. T.
Black slate	22′		164′		
Fire clay	6′		170′		
Black slate	4′		174′		
Gray shale	7′		181′		
Black slate	4′	9″	185′	9″	
Coal, Lower Verne	3′	1″	188′	10″	at 411 A. T.
Black slate		6″	189′	4″	
Fire clay	6′		195′	4″	

TEST HOLE NO. 13.

In the N. W. ¼ of the S. E. ¼ of section 15, T. 13 N., R. 4 E., the elevation above tide is 601.′

Clay	38′		38′		
Sand	1′		39′		
Clay	75′		114′		
Sand	8′		122′		
Sandrock	19′		141′		
Coal, Upper Verne	6′		147′		at 454 A. T.
Gray shale and sandrock	13′		160′		
Black slate	6′		166′		
Gray shale	4′		170′		
Fire clay, sandrock	11′		181′		
Black slate	2′		183′		
Sandy fire clay	7′		190′		
Black slate		6″	190′	6″	
Coal, Lower Verne	2′	9″	193′	3″	at 408 A. T.
Fire clay	4′		197′	3″	

TEST HOLE NO. 14.

In the N. E. ¼ of the S. W. ¼ of section 15, T. 13 N., R. 4 E., the elevation above tide is 602.′

Hard clay	20′		20′		
Soft clay	105′		125′		
Sand	5′		130′		
Gravel and clay	5′		135′		
Sand	12′		147′		
Black slate	26′		173′		
Gray shale	8′		181′		
Fire clay	7′		188′		
Black slate	3′	6″	191′	6″	
Coal, Lower Verne	3′		194′	6″	at 408 A. T.
Fire clay	7′		201′	6″	

TEST HOLE NO. 15.

At the intersection of the east and west quarter line, and the east 80 rod line of section 15, T. 13 N., R. 4 E., the elevation above tide is 600.′

Clay	80′		80′		
Hardpan	12′		92′		
Clay	10′		102′		
Hardpan	32′		134′		
Coal, Upper Rider	1′		135′		at 465 A. T.
Light slate	4′		139′		
Black slate	24′		163′		
Coal, Upper Verne		3″	163′	3″	at 437 A. T.
Black slate	4′		167′	3″	
Gray rock	13′		180′	3″	
Black slate	3′		183′	3″	
Coal	Lower Verne	3″	183′	6″	at 417 A. T.
Slate		10″	184′	4″	
Coal		6″	184′	10″	at 416 A. T.
Black slate		7″	185′	5″	
Coal		2′ 4″	187′	9″	at 413 A. T.
Gray shale		5′ 3″	193′		

TEST HOLE NO. 16.

In the S. W. ¼ of the N. E. ¼ of section 15, T. 13 N., R. 4 E., the elevation above tide is 600.′

Clay	80′		80′		
Hardpan	29′		109′		
Black clay	10′		119′		
Coal, Upper Rider	1′	2″	120′	2″	at 480 A. T.
Fire clay	3′		123′	2″	
Gray shale	8′		131′	2″	
Black slate	22′	7″	153′	9″	
Coal, Lower Verne Rider		4″	154′	1″	at 446 A. T.
Gray shale	18′	7″	172′	8″	
Black slate	7′	6″	180′	2″	
Coal, Lower Verne	3′	6″	183′	8″	at 416 A. T.
Black slate	1′	8″	185′	4″	
Fire clay	5′		190′	4″	

TEST HOLE NO. 17.

Intersection of N. and S. ¼ line and the E. and W. ¼ line of Section 15, T. 13 N., R. 4 E., the elevation above tide is 601.′

Clay	79′		79′		
Sand and gravel	25′		104′		
Clay	20′		124′		
Soft slate	10′		134′		
Gray slate	14′	2″	148′	2″	
Coal, Upper Verne	1′	3″	149′	5″	at 452 A. T.
Black slate	18′	4″	167′	9″	
Coal	1′	2″	168′	11″	at 433 A. T.
Fire clay	4′	5″	173′	4″	
Gray slate	16′		189′	4″	
Coal, Lower Verne	4′	1″	193′	5″	at 408 A. T.
Black slate		8″	194′	1″	
Fire clay	9′	3″	203′	4″	
Gray shale	24′	9″	228′	1″	
Coal, Middle Rider		3″	228′	4″	at 373 A. T.
Sand rock	....		....		

TEST HOLE HO. 18.

In the S. E. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 603.′

Clay	75′		75′		
Hardpan	45′		120′		
Slate	19′	5″	139′	5″	
Coal, Upper Verne	1′	9″	141′	2″	at 462 A. T.
Fire clay	5′	7″	146′	9″	
Light slate	17′	11″	164′	8″	
Black slate	5′	6″	170′	2″	
Slate	8′		178′	2″	
Coal, Lower Verne Rider	1′	4″	179′	6″	at 423 A. T.
Fire clay	3′	6″	183′		
Black hard slate	9′	2″	192′	2″	
Good coal, Lower Verne	3′		195′	2″	at 398 A. T.
Fire clay	2′	6″	197′	8″	

TEST HOLE NO. 19.

In the N. W. ¼ of the S. W. ¼ of Section 15, T. 13 N., R. 4 W., the elevation above tide is 603.′

Clay	74′		74′		
Hardpan	36′		110′		
Sand and gravel	9′		119′		
Fire clay	1′	2″	120′	2″	
Slate	12′	5″	132′	7″	
Coal, Upper Rider		1″	132′	8″	at 471 A. T.
Slate	30′	2″	162′	10″	
Flint rock		7″	163′	5″	
Carbonate of iron?	....		163′	5″	
Slate	4′	5″	167′	10″	
Coal and slate, Upper Verne		10″	168′	8″	at 435 A. T.
Slate	6′	10″	175′	6″	
Coal Rider of Lower Verne		2″	175′	8″	at 427 A. T.
Slate	33′		208′	8″	
Light slate	16′	5″	225′	1″	

TEST HOLE NO. 20.

In the N. W. ¼ of the S. W. ¼ of Section 15, T. 13 N., R. 4 E., Elevation above tide is 606.′

Clay	130′		130′		
Sand	7′		137′		
Black slate	26′		163′		
Fire clay	2′		165′		
Light slate	12′		177′		
Sandrock	8′		185′		
Slate	7′	10″	192′	10″	
Coal, Lower Verne		2″	193′		at 413 A. T.
Dark hard slate	7′		200′		

TEST HOLE NO. 21.

In the S. W. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., elevation above tide is 604.′

Clay	116′		116′		
Gravel	6′		122′		
Slate	2′		124′		
Coal		6″	124′	6″	at 480 A. T.
Fire clay		6″	125′		
Slate	52′	4″	177′	4″	
Black slate	1′		178′	4″	
Coal, Lower Verne Rider		8″	179′		at 425 A. T.
Black slate	6′		185′		
Fire clay	3′		188′		
Dark slate	5′	9″	193′	9″	
Coal, Lower Verne	2′	2″	195′	11″	at 408 A. T.
Slate and coal		10″	196′	9″	
Fire clay	5′	3″	202′		

TEST HOLE NO. 22.

In the S. ½ of the S. W. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., elevation above tide is 600.′

Clay	118′		118′		
Sand	2′		120′		
Fire clay	3′		123′		
Coal, Upper Rider		2″	123′	2″	at 477 A. T.
Fire clay	4′		127′	2″	
Light slate	57′		184′	2″	
Black slate	2′		186′	2″	
Coal, Lower Verne	3′		189′	2″	at 411 A. T.
Black slate	13′		202′	2″	
Coal, Middle Rider	2′	5″	204′	7″	at 395 A. T.
Fire clay	3′	2″	207′	9″	

TEST HOLE NO. 23.

In the S. W. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 602.′

Clay	116′		116′		
Slate	58′		174′		
Coal, Lower Verne	1′	9″	175′	9″	at 426 A. T.
Fire clay	25′		200′	9″	
Coal, Middle Rider		11″	201′	8″	at 401 A. T.

TEST HOLE NO. 24.

In the S. E. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 600.′

Clay	137′		137′	
Coal, Upper Rider	3′	7″	140′	7″ at 460 A. T.

TEST HOLE NO. 25.

In the N. W ¼ of the N. E. ¼ of Section 15, T. 13 N., R. 4 E., elevation above tide is 599.′

Clay	115′	6″	115′	6″
Slate	49′		164′	6″
Coal, Lower Verne Rider	2′		166′	6″ at 433 A. T.

TEST HOLE NO. 26.

In the S. E. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 601.′

Clay	86′		86′	
Hardpan	22′		108′	
Clay	17′		125′	
Sand	1′		126′	
Slate	22′	6″	148′	6″
Coal, Upper Verne		10″	149′	4″ at 452 A. T.
Fire clay	3′	8″	153′	
Gray shale	7′		160′	
Fire clay	3′		163′	
Gray shale	4′	5″	167′	5″
Coal, Lower Verne Rider	1′		168′	5″ at 433 A. T.
Black slate	3′		171′	5″
Slate	32′	5″	203′	10″
Coal, Middle Rider		7″	204′	5″ at 397 A. T.
Fire clay	3′		207′	5″
Gray slate	3′		210′	5″

TEST HOLE NO. 27.

In the S. W. ¼ of the N. E. ¼ of Section 15, T. 13 N., R. 4 E., elevation above tide is 600.′

Clay	67′		67′	
Hardpan	37′		104′	
Slate	13′	11″	117′	11″
Coal, Upper Rider	1′	6″	119′	5″ at 481 A. T.
Nothing came out	3′	7″	123′	
Coal, Upper Verne	3′	7″	126′	7″ at 474 A. T.
Slate	17′		143′	7″
Fire clay	3′	6″	147′	1″
Slate	16′	1″	163′	2″
Coal, Lower Verne	1′	7″	164′	9″ at 435 A. T.
Gray rock	30′		194′	9″
Dark slate	1′	6″	196′	3″
Slate	21′		217′	3″
Coal, Middle Rider		10″	218′	1″ at 383 A. T.
Fire clay	2′		220′	1″

TEST HOLE NO. 28.

In the S. W. ¼ of the N. E. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 600.′

Clay	86′		86′		
Hardpan	26′		112′		
Slate	6′		118′		
Coal, Upper Rider		10″	118′	10″	at 481 A. T.
Fire clay	7′		125′		
Slate	30′	3″	156′	1″	
Coal, Lower Verne Rider		1″	156′	2″	at 444 A. T.
Fire clay	13′	5″	169′	7″	
Black slate	8′	3″	177′	10″	
Light slate	7′		184′	10″	
Sandrock	8′		192′	10″	
Slate	15′	1″	207′	11″	

TEST HOLE NO. 29.

In the S. E. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 601.′

Clay	80′		80′		
Sand and gravel	9′		89′		
Clay and sand	17′		106′		
Slate	9′	6″	115′	6″	
Soft coal, Upper Rider	2′		117′	6″	at 484 A. T.
Fire clay	9′	6″	127′		
Shale	23′		150′		
Sandrock	5′		155′		
Light slate	10′	3″	165′	3″	
Coal, Upper Verne	1′		166′	3″	at 435 A. T.
Fire clay	13′	10″	180′	1″	
Blue slate	5′	2″	185′	3″	
Gray shale	8′		193′	3″	
Sandrock	4′		197′	3″	
Gray slate	4′		201′	3″	
Fire clay	1′	2″	202′	5″	
Gray shale	13′	3″	215′	8″	
Sandrock	8′		223′	8″	
Gray shale	6′		229′	8″	
Sandrock	16′		245′	8″	

TEST HOLE NO. 30.

In the S. E. ¼ of the N. E. ¼ of Section 16, T. 13 N., R. 4 E., elevation above tide is 605.′

Clay	110′		110′		
Sand and gravel	19′		129′		
Slate	21′		150′		
Fire clay	6′		156′		
Slate	14′	4″	170′	4″	
Coal, Lower Verne Rider	1′	5″	171′	9″	at 433 A. T.
Slate	2′		173′	9″	
Light slate	9′		182′	9″	
Coal, Middle Rider	1′	5″	184′	2″	at 421 A. T.
Fire clay	4′		188′	2″	
Slate	25′		213′	2″	
Sandrock	5′		218′	2″	
Slate	13′		231′	2″	

TEST HOLE NO. 31.

In the N. ½ of the S. W. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 606.′

Clay	120′		120′		
Hardpan	8′		128′		
Sand	3′		131′		
Slate	3′	8″	134′	8″	
Coal, Upper Rider		10″	135′	6″	at 471 A. T.
Fire clay	1′	8″	137′	2″	
Black slate	6′	2″	143′	4″	
Gray slate	6′	2″	149′	6″	
Coal, Upper Verne		4″	149′	10″	at 456 A. T.
Gray shale	10′		159′	10″	
Fire clay	3′		162′	10″	
Slate	1′	10″	164′	8″	
Coal, Lower Verne Rider	1′	5″	166′	1″	at 440 A. T.
Gray slate	18′		184′	1″	
Sandrock	1′		185′	1″	
Gray rock	10′		195′	1″	

TEST HOLE NO. 32.

In the N. ½ of the S. W. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 605.′

Clay	68′		68′		
Stone and gravel	15′		83′		
Clay	30′		113′		
Sandrock	9′		122′		
Slate	2′		124′		
Gravel rock (conglomerate?)	6′		130′		
Slate	40′		170′		
Coal, Lower Verne Rider	2′	6″	172′	6″	at 433 A. T.
Fire clay	3′		175′	6″	
Slate	7′	8″	183′	2″	
Coal, Lower Verne	2′	4″	185′	6″	at 420 A. T.
Black slate		10″	186′	4″	
Fire clay	2′		188′	4″	
Slate	10′		198′	4″	
Coal, Middle Rider		7″	198′	11″	at 406 A. T.
Gray slate	17′		215′	11″	

TEST HOLE NO. 33.

In the S. E. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 600.′

Clay	75′		75′		
Hardpan and sand	44′	6″	119′	6″	
Gray slate	21′	2″	140′	8″	
Coal, Upper Verne	4′	7″	145′	3″	at 455 A. T.
Fire clay	6′	9″	152′		
Sandrock	2′	8″	154′	8″	
Gray shale	10′		164′	8″	
Black slate	20′		184′	8″	
Coal, Lower Verne Rider		4″	185′		at 415 A. T.
Black slate	7′	4″	192′	4″	
Fire clay	3′		195′	4″	
Black slate		6″	195′	10″	
Poor coal, Lower Verne	2′		197′	10″	at 402 A. T.
Fire clay	2′	6″	200′	4″	
Sandrock	10′	8″	211′		

TEST HOLE NO. 34.

In the N. E. ¼ of the N. E. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 601.′

Clay	79′		79′		
Hardpan	24′		103′		
Black slate	4′		107′		
Sandrock	10′		117′		
Gray shale	17′		134′		
Fire clay	6′		140′		
Coal, Upper Verne		6″	140′	6″	at 461 A. T.
Fire clay	4′		144′	6″	
Gray shale	16′	4″	160′	10″	
Black slate		4″	161′	2″	
Gray rock	27′	4″	188′	6″	
Sandrock	1′	6″	190′		

TEST HOLE NO. 35.

In the N. W. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 605.′

Clay	85′		85′		
Hardpan	37′		122′		
Sandrock	7′		129′		
Gray shale	15′	8″	144′	8″	
Black slate	26′	6″	171′	4″	
Coal, Lower Verne Rider	1′	6″	172′	10″	at 432 A. T.
Fire clay	3′		175′	10″	
Black slate		6″	176′	4″	
Fire clay	10′	8″	187′		
Gray shale	23′		210′		
Fire clay	3′		213′		

TEST HOLE NO. 36.

In the N. W. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 607.′

Clay	82′		82′		
Sand and gravel	10′		92′		
Clay	8′		100′		
Sand and gravel	18′		118′		
Hardpan	17′		135′		
Coal, Upper Verne		3″	135′	3″	at 472 A. T.
Sandrock	16′	9″	152′		
Slate	1′		153′		
Fire clay	1′		154′		
Slate	4′		158′		
Sandrock	3′		161′		
Slate	1′	6″	162′	6″	
Coal, Lower Verne Rider	1′	3″	163′	9″	at 443 A. T.
Fire clay	3′	2″	166′	11″	
Slate	8′		174′	11′	
Coal, Lower Verne	2′	11½″	177′	10½″	at 429 A. T.
Black slate		4½″	178′	3″	
Fire clay	7′	8″	185′	11″	
Slate	3′		188′	11″	
Sandrock	21′		209′	11″	

TEST HOLE NO. 37.

In the N. W. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 605.′

Clay	73′		73′		
Hardpan	44′		117′		
Sand	14′		131′		
Clay	3′	5″	134′	5″	
Slate	23′	5″	157′	10′	
Coal		5″	158′	3″	at 447 A. T.
White slate	10′	11″	169′	2″	
Coal, Lower Verne Rider	1′	5″	170′	7″	at 434 A. T.
Fire clay	4′	11″	175′	6″	
Coal, Lower Verne	1′	7″	177′	1″	at 428 A. T.
Fire clay	4′	7″	181′	8″	
Dark slate	2′		183′	8″	
Fire clay	7′	5″	191′	1″	
Slate	2′	2″	193′	3″	
Coal, Middle Rider	1′	2″	194′	5″	at 411 A. T.
Fire clay	2′	4″	196′	9″	
Coal		6″	197′	3″	at 408 A. T.
Fire clay and slate	19′		216′	3″	

TEST HOLE NO. 38.

In the N. W. ¼ of the N. W. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 607.′

Clay	90′		90′		
Hardpan	30′		120′		
Clay	12′		132′		
Slate	33′		165′		
Coal, Lower Verne Rider		2″	165′	2″	at 442 A. T.
Light slate	1′	6″	166′	8″	
Fire clay	4′	2″	170′	10″	
Slate	5′		175′	10″	
Soft coal, Lower Verne	2′	7½″	178′	5½″	at 429 A. T.
Fire clay	11′	3½″	189′	8½″	
Slate		6″	190′	2½″	
Fire clay	8′	6″	198′	8½″	
Slate	3′		201′	1½″	
Sandrock	2′		203′	8½″	
Slate	16′		219′	8½″	

TEST HOLE NO. 39.

In the S. W. ¼ of the S. W. ¼ of Section 10, T. 13 N., R. 4 E., the elevation above tide is 608.′

Clay	73′		73′		
Hardpan	74′		147′		
Sand	11′	2″	158′	2″	
Clay	10′	2″	168′	4″	
Coal, Lower Verne Rider	2′	4″	170′	8″	at 437 A. T.
Fire clay	8′	7″	179′	3″	
Slate	1′	5″	180′	8″	
Coal, Lower Verne		6″	181′	2″	at 427 A. T.
Black slate	19′		200′	2″	
Light slate		6″	200′	8″	
Black slate	19′	4″	220′		
Coal, Middle Rider		3″	220′	3″	at 388 A. T.
Slate		2″	220′	5″	
Coal, Saginaw Coal	1′	3″	221′	8″	at 386 A. T.
Sandrock	2′	5″	224′	1″	

TEST HOLE NO. 40.

In the S. W. ¼ of the N. E. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 600.′ This record is very likely inaccurate.

Sand	16′		16′		
Gravel	2′		18′		
Light slate	18′	4″	36′	4″	
Coal	4′	5″	40′	9″	at 559 A. T.
Fire clay	6′	2″	46′	11″	
Light slate	32′	1″	79′		
Fire clay	3′		82′		
Light slate	8′		90′		
Coal	1′	5″	91′	5″	at 509 A. T.
Fire clay	4′		95′	5″	
Slate	25′		120′	5″	

Valley Coal Mining Co.

Test Holes Nos. 41-79.

TEST HOLE NO. 41.

In the S. E. ¼ of the S. W. ¼ of Section 6, T. 13 N., R. 5 E., the elevation above tide is 580-583.′

Clay	83′		83′		
Coal, Upper Rider	1′	3″	84′	3″	at 499 A. T'
Fire clay	2′		86′	3″	
Light shale	6′		92′	3″	
Sandrock	4′	6″	96′	9″	
Dark shale	7′		103′	9″	
Light shale	8′		111′	9″	
Black slate	3′		114′	9″	
Coal, Upper Verne		11″	115′	8″	at 467 A. T.
Fire clay	4′		119′	8″	
Light shale	6′		125′	8″	

TEST HOLE NO. 42.

In the N. W. ¼ of the N. E. ¼ of Section 7, T. 13 N., R. 5 E., Elevation above tide is 580-583.′

Clay	82′		82′		
Shale	1′		83′		
Slate	2′		85′		
Salzburg coal	1′	7″	86′	7″	at 496 A. T.
Fire clay	3′		89′	7″	
Sandrock	6′		95′	7″	
Light shale	8′		103′	7″	
Light slate	3′		106′	7″	
Sandrock	8′		114′	7″	
Shale	2′		116′	7″	
Slate	5′		121′	7″	
Coal, Upper Verne	2′	5″	124′		at 459 A. T.

TEST HOLE NO. 43.

In the N. W. ¼ of the N. E. ¼ of Section 12, T. 13 N., R. 4 E., elevation above tide is 584.′

Clay	77′	77′	
Hardpan	11′	88′	
Sand	27′	115′	

TEST HOLE NO. 44.

In the S. E. ¼ of the N. W. ¼ of Section 12, T. 13 N., R. 4 E., elevation above tide is 585.′

Clay	77′	77′	
Slate	5′ 6″	82′ 6″	
Salzburg coal	3′ 6″	86′	at 499 A. T.
Fire clay	1′ 6″	87′ 6″	
Sand rock	2′ 6″	90′	
Shale	3′	93′	
Slate	4′	97′	
Coal, Upper Verne Rider	1′ 6″	98′ 6″	at 487 A. T.
Fire clay	2′	100′ 6″	
Gray sandrock	4′	104′ 6″	
Shale	6′	110′ 6″	
Sandrock	5′	115′ 6″	
Shale	3′	118′ 6″	
Gray sandrock	4′	122′ 6″	

TEST HOLE NO. 45.

In the N. W. ¼ of the N. E. ¼ of Section 12, T. 13 N., R. 4 E., the elevation above tide is 584.′

Clay	77′	77′	
Hardpan	2′ 4″	79′ 4″	
Sand	1′	80′ 4″	
Sandrock	1′ 7″	81′ 11″	
Dark shale	2′ 5″	84′ 4″	
Dark slate	1′ 10″	86′ 2″	
Salzburg coal	3′ 4″	89′ 6″	at 495 A. T.
Gray sandrock	1′ 4″	90′ 10″	
Fire clay	2′ 6″	93′ 4″	
Shale	3′	96′ 4″	
Slate	3′ 8″	100′	
Coal, Upper Verne Rider	1′ 2″	101′ 2″	at 483 A. T.
Fire clay	1′ 4″	102′ 6″	
Shale	2′	104′ 6″	

TEST HOLE NO. 46.

In the N. W. ¼ of the N. E. ¼ of Section 12, T. 13 N., R. 4 E., the elevation above tide is 584.′

Clay	76′	76′	
Hardpan	2′	78′	
Sand	1′ 6″	79′ 6″	
Sandrock	3′ 4″	82′ 10″	
Dark shale	2′	84′ 10″	
Slate	3′ 6″	88′ 4″	
Ribbon of coal, Upper Rider	....	....	at 495 A. T.
Fire clay	8′	96′ 4″	
Sandrock	11′	107′ 4″	

TEST HOLE NO. 47.

In the N. W. ¼ of the N. E. ¼ of Section 12, T. 13 N., R. 4 E., elevation above tide is 584.′

Clay	75′	75′	
Hardpan	3′	78′	
Sand	3′ 6″	81′ 6″	
Shale	4′	85′ 6″	
Slate	3′ 6″	89′	

Salzburg coal	2′	8″	91′ 8″	at 492 A. T.
Fire clay		10″	92′ 6″	
Shale	3′		95′ 6″	
Sandrock	4′	4″	99′ 10″	
Slate	3′		102′ 10″	
Coal, Upper Rider	1′	6″	104′ 4″	at 480 A. T.
Fire clay	1′		105′ 4″	
Shale	2′		107′ 4″	

TEST HOLE NO. 48.

In the northeast corner of Section 12, T. 13 N., R. 4 E., the elevation above tide is 583.′

Clay	75′		75′	
Hardpan	1′	10″	76′ 10″	
Sand	4′		80′ 10″	
Shale	6′		86′ 10″	
Slate	2′	4″	89′ 2″	
Salzburg coal	1′	2″	90′ 4″	at 493 A. T.
Fire clay and shale	5′		95′ 4″	
Shale	6′	6″	101′ 10″	
Black slate	3′		104′ 10″	
Fire clay	3′		107′ 10″	
Shale	4′		111′ 10″	
Gray sandrock	6′		117′ 10″	
White sandrock	4′		121′ 10″	

TEST HOLE NO. 49.

In the S. E. ¼ of the S. E. ¼ of Section 6, T. 13 N., R. 5 E., the elevation above tide is 582.′

Clay	75′	6″	75′ 6″	
Hardpan	7′	9″	83′ 3″	
White sandrock	2′		85′ 3″	
Shale	6′		91′ 3″	
Slate	3′		94′ 3″	
Coal, Upper Rider	1′	2″	95′ 5″	at 487 A. T
Fire clay	1′	6″	96′ 11″	
Shale	16′		112′ 11″	
Dark shale	5′		117′ 11″	
Slate	2′		119′ 11″	
Light shale	14′		133′ 11″	
Dark shale	3′		136′ 11″	

TEST HOLE NO. 50.

In the N. E. ¼ of the N. W. ¼ of Section 7, T. 13 N., R. 5 E., elevation above tide is 583.′

Clay	70′		70′	
Hardpan	3′		73′	
Shale	5′		78′	
Slate	1′	2″	79′ 2″	
Soapstone	3′		82′	
Shale and rock	5′		87′	
Slate	1′		88′	
Salzburg coal	2′	2″	90′ 4″	at 493 A. T.
Fire clay		8″	91′	

TEST HOLE NO. 51.

In the N. E. ¼ of the N. W. ¼ of Section 7, T. 13 N., R. 5 E., elevation above tide is 583.′

Clay	72′		72′		
Hardpan	2′		74′		
Shale	2′	6″	76′	6″	
Slate	2′	6″	79′		
Salzburg coal	1′	7″	80′	7″	at 502 A. T.
Fire clay	1′	6″	82′	1″	
Shale	7′		89′	1″	
Sandrock	8′		97′	1″	
Shale	7′		104′	1″	
Sandrock	36′		140′	1″	

TEST HOLE NO. 52.

In the N. W. ¼ of the N. E. ¼ of Section 12, T. 13 N., R. 4 E., elevation above tide is 584.′

Clay	72′		72′		
Hardpan	5′		77′		
Sand	8′		85′		

TEST HOLE NO. 53.

In the N. W. ¼ of the N. E. ¼ of Section 12, T. 13 N., R. 4 E., elevation above tide is 584.′

Clay	73′		73′		
Hardpan	5′		78′		
Sand	1′		79′		
Shale	4′		83′		
Slate	3′	8″	86′	8″	
Salzburg coal	4′	8″	91′	4″	at 493 A. T.
Fire clay	2′		93′	4″	

TEST HOLE NO. 54.

In the N. W. ¼ of the N. E. ¼ of Section 7, T. 13 N., R. 5 E., elevation above tide is 583.′

Clay	84′		84′		
Sand	6′		90′		
Shale	8′		98′		
Sandrock	4′		102′		
Light shale	3′		105′		
Slate	5′	6″	110′	6″	
Coal, Rider	1′	6″	112′		at 471 A. T.
Fire clay	3′		115′		
Sandrock	6′		121′		
Slate	3′		124′		
Coal, Upper Verne	1′		125′		at 458 A. T.
Fire clay	2′	6″	127′	6″	

TEST HOLE NO. 55.

In the S. W. ¼ of the S. E. ¼ of Section 6, T. 13 N., R. 5 E., elevation above tide is 583.′

Clay	82′	6″	82′	6″	
Shale	1′	6″	84′		
Slate	2′		86′		
Coal, Upper Rider?		5″	86′	5″	at 497 A. T.
Fire clay	1′	6″	87′	11″	
Sandrock	6′		93′	11″	
Light shale and slate	9′		102′	11″	

TEST HOLE NO. 56.

In the S. E. ¼ of the S. W. ¼ of Section 6, T. 13 N., R. 5 E., elevation above tide is 583.′

Clay	84′		84′	
Shale	4′		88′	
Slate	2′		90′	
Coal, Upper Rider	1′	8″	91′	8″ at 491 A. T.
Fire clay	2′		93′	8″
Sandrock	7′		100′	8″
Shale	8′		108′	8″
Sandrock	6′		114′	8″
Shale	5′		119′	8″
Slate	2′		121′	8″
Coal, Upper Verne	1′	5″	123′	1″ at 460 A. T.

TEST HOLE NO. 57.

In the S. W. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., elevation above tide is 583.′

Clay	81′		81′	
Dark slate	15′		96′	
Coal, Upper Rider		3″	96′	3″ at 487 A. T.
Fire clay	8′		104′	3″
Slate	1′		105′	3″
Coal		1″	105′	4″ at 478 A. T.
Fire clay		4″	105′	8″
Coal, Upper Verne		4″	106′	at 477 A. T.
Fire clay	4′		110′	
Light slate	8′		118′	
Dark slate	7′		125′	
Light slate	12′		137′	
Sandrock	1′	2″	138′	2″

TEST HOLE NO. 58.

In the S. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., elevation above tide is 583.′

Clay	79′	7″	79′	7″
Hardpan	2′	2″	81′	9″
Fire clay	2′		83′	9″
Dark slate	5′		88′	9″
Coal, Upper Rider		10″	89′	7″ at 493 A. T.
Light slate	1′	6″	91′	1″
Fire clay	3′		94′	1″
Dark slate	19′		113′	1″
Coal, Upper Verne	2′	9″	115′	10″ at 467 A. T.

TEST HOLE NO. 59.

In the center of the N. E. ¼ of Section 5, T. 15 N., R. 4 E., elevation above tide is 615.′

Clay	127′	6″	127′	6″
Slate	145′	8″	273′	2″
Sandrock and clay	149′	10″	423′	
Black slate	157′	6″	580′	6″
Coal	2′		582′	6″ at 33 A. T.

TEST HOLE NO. 60.

In the S. E. ¼ of the S. E. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 589.′

Clay	89′	89′	
Sand	12′	101′	
Slate	7′	108′	
Coal, Upper Rider	10′?	118′	at 471 A. T.
Fire clay	7′	125′	
Slate	7′	132′	
Coal, Upper Verne	1′ 9″	133′ 9″	at 455 A. T.
Fire clay	4′	137′ 9″	
Slate	24′ 6″	162′ 3″	

TEST HOLE NO. 61.

In the S. E. ¼ of the S. E. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 590.′

Clay	86′	86′	
Sand	3′	89′	
Hardpan	5′	94′	
Gravel	4′	98′	
Soapstone	7′	105′	
Sand	16′	121′	
Soapstone	10′	131′	
Sandrock	26′	157′	

TEST HOLE NO. 62.

In the S. E. ¼ of the S. E. ¼ of Section 36, T. 14 N., R. 4 E., the elevation above tide is 589.′

Clay	89′	89′	
Sand and shale	4′ 5″	93′ 5″	
Slate	18′ 9″	112′ 2″	
Coal, Upper Verne	2′ 10″	115′	at 474 A. T.
Slate	8′ 7″	123′ 7″	
Sandrock	....	....	

TEST HOLE NO. 63.

In the S. W. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., elevation above tide is 583.′

Clay	83′	83′	
Slate	7′ 6″	90′ 6″	
Coal, Upper Rider	4″	94′ 6″	at 489 A. T.

TEST HOLE NO. 64.

In the S. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., elevation above tide is 583.′

Clay	82′	82′	
Slate	27′	109′	
Coal, Upper Verne	2′ 5½″	111′ 5½″	at 472 A. T.

TEST HOLE NO. 65.

In the N. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., elevation above tide is 584.′

Clay	92′	92′	
Sand and clay shale	10′	102′	
Slate	8′ 10″	110′ 10″	
Coal, Upper Verne	2′ 8″	113′ 6″	at 471 A. T.

TEST HOLE NO. 66.

In the N. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., the elevation above tide is 582.′

Clay	94′ 7″	94′ 7″	
Slate	8′ 8″	103′ 3″	
Coal, Upper Rider	2′ 7½″	105′ 10½″	at 476 A. T.
Fire clay	6′	111′ 10½″	
Sandrock	....	....	

TEST HOLE NO. 67.

In the S. E. ¼ of the S. W. ¼ of Section 6, T. 13 N., R. 5 E., the elevation above tide is 583.′

Clay	73′	73′	
Hardpan	10′	83′	
Soft shale	3′	86′	
Slate	12′	98′	
Sandrock	30′	128′	
Slate and sandrock	5′	133′	

TEST HOLE NO. 68.

In the N. E. ¼ of the S. E. ¼ of Section 1, T. 13 N., R. 4 E., the elevation above tide is 583.′

Clay	81′ 6″	81′ 6″	
Slate	7′ 6″	89′	
Salzburg coal	3′ 3″	92′ 3″	at 491 A. T.

TEST HOLE NO. 69.

In the S. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., the elevation above tide is 583.′

Clay	70′	70′	
Hardpan	13′	83′	
Fire clay	2′	85′	
Slate	4′	89′	
Coal, Upper Rider	1′ 5″	90′ 5″	at 493 A. T.
Fire clay	2′	92′ 5″	
Slate	7′ 11″	100′ 4″	
Sandrock	3′ 10″	104′ 2″	

TEST HOLE NO. 70.

In the S. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., the elevation above tide is 583.′

Clay	83′ 4″	83′ 4″	
Light slate	15′	98′ 4″	
Dark slate	4′ 2″	102′ 6″	
Coal, Upper Rider	2′ 5″	104′ 11″	at 478 A. T.
Slate	3′ 1″	108′	
Good fire clay	8′	116′	
Slate	10′	126′	
Coal, Upper Verne	1′	127′	at 456 A. T.
Fire clay	1′	128′	
Slate	6′	134′	

TEST HOLE NO. 71.

In the N. E. ¼ of the S. E. ¼ of Section 1, T. 13 N., R. 4 E., elevation above tide is 583.′

Clay	80′		80′		
Slate	2′		82′		
Sandrock	3′		85′		
Dark slate	1′		86′		
Fire clay	5′	2″	91′	2″	
Light slate	9′	3″	100′	5″	
Dark slate	2′	9″	103′	2″	
Fire clay	1′		104′	2″	
Slate	6′	1″	110′	3″	
Slate and rock	10′		120′	3″	

TEST HOLE NO. 72.

In the S. E. ¼ of the S. W. ¼ of Section 6, T. 13 N., R. 5 E., the elevation above tide is 583.′

Clay	81′		81′		
Slate	11′		92′		
Coal, Upper Rider		4″	92′	4″	at 491 A. T.
Soft sandrock	1′		93′	4″	
Hard sandrock	8′		101′	4″	
Slate	5′	5″	106′	9″	
Sandrock	7′	5″	114′	2″	
Slate	8′		122′	2″	
Coal, Upper Verne	1′	10″	124′		at 459 A. T.

TEST HOLE NO. 73.

In the S. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R .4 E., the elevation above tide is 582.′

Clay	74′		74′		
Hardpan	8′		82′		
Shale	2′		84′		
Slate	4′		88′		
Slate and coal		6″	88′	6″	
Coal, Upper Rider	11′	5″	89′	6″	at 493 A. T.
Fire clay	2′	6″	92′		
Slate	7′	2″	99′	2″	
Gray rock	7′	2″	106′	4″	
Gray rock	2′		108′	4″	
Slate	3′	1″	111′	5″	
Coal, Upper Verne	2′		113′	5″	at 469 A. T.
Fire clay	2′	9″	116′	2″	
Sandrock	2′		118′	2″	
Fire clay and slate	16′	10″	135′		
Slate	2′	7″	137′	7″	

TEST HOLE NO. 74.

In the S. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., elevation above tide is 583.′

Clay	82′		82′		
Drift coal	2′	1″	84′	1″	
Fire clay	2′		86′	1″	
Slate	3′	6″	89′	7″	
Coal, Upper Rider	1′	5″	91′		at 492 A. T.
Fire clay	3′	1′	94′	1″	
Slate	12′	6″	106′	7″	
Black slate	3′	1″	109′	8″	
Bone coal		8″	110′	4″	
Coal, Upper Verne	3′	1″	113′	5″	at 470 A. T.
Fire clay	3′	7″	117′		

TEST HOLE NO. 75.

In the S. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., the elevation above tide is 583.′

Clay	83′	83′	
Slate	2′	85′	
Fire clay	3′ 6″	88′ 6″	
Light slate	7′	95′ 6″	
Dark slate	17′ 6″	113′	
Coal, Upper Verne	3′	116′	at 467 A. T.
Fire clay	1′ 2″	117′ 2″	

TEST HOLE NO. 76.

In the S. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., elevation above tide is 583.′

Clay	73′	73′	
Hardpan	6′ 3″	79′ 3″	
Salzburg coal and slate	2′ 2″	81′ 5″	at 502 A. T.
Fire clay	3′	84′ 5″	
Slate	5′	89′ 5″	
Fire clay	1′ 4″	90′ 9″	
Slate	14′ 8″	105′ 5″	
Coal, Upper Verne	3′ 4″	108′ 9″	at 474 A. T.

TEST HOLE NO. 77.

In the N. W. ¼ of the S. W. ¼ of Section 6, T. 13 N., R. 5 E., elevation above tide is 583.′

Clay	86′	86′	
Hardpan	12′	98′	
Light slate	9′	107′	
Sandrock	14′ 6″	121′ 6″	

TEST HOLE NO. 78.

In the S. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E., the elevation above tide is 583.′

Clay	82′ 7″	82′ 7″	
Slate	10′ 11″	93′ 6″	
Coal, Upper Rider	8″	94′ 2″	at 489 A. T.
Fire clay	7′ 5″	101′ 7″	
Slate	2′	103′ 7″	
Slate and sandrock	15′	118′ 7″	
Slate	9′ 2″	127′ 9″	

TEST HOLE NO. 79.

In the S. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4. E. the elevation above tide is 583.′

Clay	79′	79′	
Drift coal	1′ 10″	80′ 10″	
Fire clay	2′	82′ 10″	
Slate	9′ 3″	92′ 1″	
Coal, Upper Rider	1′	93′ 1″	at 490 A. T.
Fire clay	3′ 9″	96′ 10″	
Slate	9′ 11″	106′ 9″	
Hard slate and bone	....	....	
Coal, Upper Verne	4′	110′ 9″	at 473 A. T.
Coal	2′ 8″	113′ 5″	

Drillings from the N. E. Part of Frankenlust and S. E. Part of Monitor, Bay Co. Hecla Portland Cement Co. of Bay City. The Elevations Above Sea Level Were Determined by Spirit Level.

Test Holes Nos. 80-117.

TEST HOLE NO. 80.

In the S. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 584.0.′

Clay	68′		68′		
Black slate	4′		72′		
Dark gray shale	11′		83′		
Fire clay	6′		89′		
Gray shale	12′		101′		
Black slate		6″	101′	6″	
Coal, Upper Rider		6″	102′		at 482 A. T.
Fire clay	5′		107′		
Gray shale	21′		128′		
Black slate	2′		130′		
Coal, Upper Verne		9″	130′	9″	at 453 A. T.
Fire clay	3′	3″	134′		
Gray shale	2′	6″	136′	6″	
Coal, Lower Verne Rider		6″	137′		at 447 A. T.
Fire clay	3′		140′		
Gray shale	10′		150′		
Hard rock		6″	150′	6″	
Black slate	1′		151′	6″	
Coal, Lower Verne		6″	152′		at 432 A. T.
Fire clay	4′		156′		
Gray shale	2′		158′		
Coal	1′	4″	159′	4″	at 425 A. T.
Fire clay	4′		163′	4″	
Gray shale	4′	8″	168′		
Black slate	22′		190′		
Coal, Saginaw Coal Rider	3′		193′		at 391 A. T.
Fire clay	1′		194′		

TEST HOLE NO. 81.

In the S. E. ¼ of the S. W. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 590.′

Clay	50′		50′		
Sandy clay	30′		80′		
Hardpan	40′		120′		
Horizon of Upper Verne	....		....		at 470 A. T.
Fire clay	5′		125′		
Light shale	13′		138′		
Gray shale	10′		148′		
Black slate	7′		155′		
Fire clay	4′		159′		
Black slate		6″	159′	6″	
Fire clay	3′	6″	163′		
Sandy shale	32′		195′		

TEST HOLE NO. 82.

In the S. E. ¼ of the S. W. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 591.′

Clay	50′		50′	
Sandy clay	25′		75′	
Sand and gravel	34′		109′	
Gray shale	9′		118′	
Coal, Upper Verne		6″	118′	6″ at 473 A. T.
Fire clay	2′	6″	121′	
Sandy shale	24′		145′	
Dark gray shale	15′		160′	
Black slate	6′		166′	
Coal, Lower Verne	2′	8″	168′	8″ at 422 A. T.
Black slate		4″	169′	
Fire clay	7′		176′	
Gray shale	20′		196′	
Black slate	10′		206′	
Coal, Middle Rider	1′	4″	207′	4″ at 384 A. T.
Fire clay	1′	8″	209′	
Light shale	21′		230′	
Dark shale	9′		239′	
White sandrock	3′		242′	

TEST HOLE NO. 83.

1900′ S. of the center of Section 2, T. 13 N., R. 4 E., elevation above tide is 592.′

Sandy clay	75′		75′	
Sand and gravel	35′		110′	
Coal, Upper Rider	1′		111′	at 481 A. T.
Sandy fire clay	11′		122′	
Dark gray shale	15′		137′	
Black slate	3′		140′	
Coal, Upper Verne	2′	6″	142′	6″
Sandy fire clay	6′		148′	6″ at 450 A. T.
Gray shale	3′		151′	6″
Coal, Lower Verne		6″	152′	at 440 A. T.
Sandy fire clay	4′		156′	
Gray shale	14′		170′	
Black slate	18′		188′	
Coal, Middle Rider	3′		191′	at 401 A. T.
Black slate		6″	191′	6″
Sandy fire clay	1′	6″	193′	

TEST HOLE NO. 84.

In the N. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 591.′

Clay	78′		78′	
White soapstone	2′		80′	
Gray shale	5′		85′	
Gray sandrock	4′		89′	
Gray sandy shale	8′		97′	
Black slate		6″	97′	6″
Coal, Upper Rider		10″	98′	4″ at 483 A. T.
Gray shale	28′	8″	127′	
Black slate	10′		137′	
Coal, Upper Verne	2′	7″	139′	7″ at 451 A. T.
Fire clay	4′		143′	7″
Dark gray shale	16′	5″	160′	
Black slate	1′	6″	161′	6″
Coal, Lower Verne		6″	162′	at 429 A. T.

TEST HOLE NO. 85.

In the N. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 591.′

Clay	80′		80′	
Gravel	4′		84′	
Black slate	2′		86′	
Salzburg coal		6″	86′	6″ at 505 A. T.
Fire clay	4′		90′	6″
Gray shale	24′	6″	115′	
Coal, Upper Rider		6″	115′	6″ at 476 A. T.
Sandy fire clay	7′	6″	123′	
Sandy shale	15′		138′	
Dark sandy shale	12′		150′	
Black slate	8′		158′	
Coal, Lower Verne	3′		161′	at 430 A. T.
Black slate	1′		162′	
Fire clay	4′		166′	
Sandy shale	9′		175′	
Black slate	19′		194′	
Coal, Middle Rider	2′	5″	196′	5″ at 395 A. T.
Black slate		7″	197′	
Sandy fire clay	9′		206′	

TEST HOLE NO. 86.

In the N. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 593.′

Sand	3′	3′	
Sandy clay	77′	80′	
Hardpan	12′	92′	
Sand	21′	113′	
Fire clay	3′	116′	
Gravel	2′	118′	
Gray shale	12′	130′	
Black slate	5′	135′	
Coal, Upper Verne	3′	138′	at 455 A. T.
Fire clay	4′	142′	
Sandrock	3′	145′	

TEST HOLE NO. 87.

In the N. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 597.′

Sand	4′	4′	
Sandy clay	64′	68′	
Hardpan	48′	116′	
Black slate	3′	119′	
Coal, Main Rider of Upper Verne	1′	120′	at 477 A. T.
Fire clay	6′	126′	
Coal, Upper Rider	1′	127′	at 470 A. T.
Fire clay	3′	130′	
Gray shale	14′	144′	
Black slate	4′	148′	
Coal, Upper Verne	3′	151′	at 446 A. T.
Fire clay	4′	155′	

TEST HOLE NO. 88.

In the N. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 594.′

Sandy clay	68′		68′	
Hardpan	15′		83′	
Sandy clay	12′		95′	
Shale	13′		108′	
Hardpan	4′		112′	
Shale	5′		117′	
Coal, Main Rider of Upper Verne	1′		118′	at 476 A. T.
Fire clay	4′		122′	
Shale	4′		126′	
Coal	1′	8″	127′	8″ at 466 A. T.
Fire clay } Upper Verne	3′	4″	131′	
Coal	1′	6″	132′	6″ at 462 A. T.
Fire clay	5′	6″	138′	
Gray shale	6′		144′	
Black slate	5′		149′	
Coal, Lower Verne	3′		152′	at 442 A. T.

TEST HOLE NO. 89.

In the N. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 594.′

Sand	2′		2′	
Sandy clay	48′		50′	
Clay	12′		62′	
Hardpan	12′		74′	
Clay	3′		77′	
Hardpan	4′		81′	
Clay	5′		86′	
Sandy clay	12′		98′	
Clay	5′		103′	
Dark shale	9′		112′	
Light shale	4′		116′	
Coal, Upper Rider	1′		117′	at 477 A. T.
Fire clay	6′		123′	
Black slate	3′		126′	
Fire clay	4′		130′	
Coal, Upper Verne	1′	6″	131′	6″ at 463 A. T.
Fire clay	6′	6″	138′	
Gray shale	5′		143′	
Black slate	5′		148′	
Coal, Lower Verne	3′		151′	at 443 A. T.
Fire clay	6′	3″	157′	3″
Black slate	29′		186′	3″
Coal, Middle Rider	2′	8″	188′	11″ at 405 A. T.
Black slate		8″	192′	7″
Fire clay	5′	6″	195′	1″

TEST HOLE NO. 90.

In the N. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., near shaft of Hecla Coal and Portland Cement Co., cf. hole No. 334, elevation above tide is 598.′

Sandy clay	75′		75′	
Hardpan	38′		113′	
Black slate	6′		119′	
Coal	1′	6″	120′	6″ at 478 A. T.
Fire clay } Riders of Upper Verne	1′		121′	6″
Coal		8″	122′	2″ at 476 A. T.
Sandy fire clay	2′	10′	125′	

Black slate	15′		140′		
Coal, Upper Verne	2′	10″	142′	10″	at 455 A. T.
Sandy fire clay	4′	2″	147′		
Black slate	28′		175′		
Coal, Lower Verne	3′		178′		at 420 A. T.

TEST HOLE NO. 91.

In the N. E. ¼ of the S. W. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 584.′

Clay	53′		53′		
Hardpan	11′		64′		
Sand and gravel	31′		95′		
Sandy clay	24′		119′		
Black slate	10′		129′		
Coal, Upper Verne	2′	8″	131′	8″	at 452 A. T.
Black slate		4″	132′		
Sandy fire clay	8′		140′		
Sandy shale	8′		148′		
Black slate	22′		170′		
Coal, Lower Verne?	3′		173′		at 411 A. T.
Sandy fire clay	2′		175′		

TEST HOLE NO. 92.

In the N. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 594.′

Sand	3′		3′		
Sandy clay	12′		15′		
Clay	47′		62′		
Hardpan	10′		72′		
Blue clay	8′		80′		
Hardpan	3′		83′		
Clay	10′		93′		
Black slate	7′		100′		
Sandrock	8′		108′		
Coal, Upper Rider	1′		109′		at 485 A. T.
Fire clay	2′		111′		
Sandrock	6′		117′		
Black slate	2′		119′		
Coal	2′		121′		at 473 A. T.
Fire clay	2′		123′		
Coal		6″	123′	6″	at 471 A. T.
Fire clay	5′	6″	129′		
Coal	1′		130′		at 464 A. T.
Fire clay	3′		133′		
Gray shale	7′		140′		
Black slate	4′		144′		
Coal, Lower Verne	3′	1″	147′	1″	at 447 A. T.
Fire clay	4′		151′	1″	

(Upper Verne)

TEST HOLE NO. 93.

In the N. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 593.′

Sandy clay	30′		30′		
Clay	48′		78′		
Sandy shale	16′		94′		
Black slate	1′		95′		
Coal, Upper Rider		6″	95′	6″	at 498 A. T.
Fire clay	7′	6″	103′		
Gray shale	19′		122′		
Black slate	6′		128′		

Coal, Upper Verne	2′	11″	130′	11″	at 462 A. T.
Fire clay	4′	1″	135′		
Sandrock	28′		163′		
Coal, Lower Verne	1′		164′		at 429 A. T.
Sandy shale	30′		194′		
Sandrock	6′		208′		

TEST HOLE NO. 94.

In the S. E. ¼ of the N. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 584.′

Sandy clay	40′		40′		
Clay	28′		68′		
Black slate	13′		81′		
Sandy shale	11′		92′		
Coal, Rider of Upper Verne	1′		93′		at 491 A. T.
Sandy shale	9′		102′		
Black slate	3′		105′		
Coal, Main Rider, Upper Verne	2′	6″	107′	6″	at 477 A. T.
Fire clay		6″	108′		
Coal	1′		109′		
Fire clay	3′		112′		
Coal		4″	112′	4″	at 472 A. T.
Dark gray shale	7′	6″	119′	10″	
Black slate	2′	6″	122′	4″	
Coal, Upper Verne	3′	1″	125′	5″	at 459 A. T.
Black slate		5″	125′	10″	
Fire clay	4′		129′	10″	
Gray shale	15′		144′	10″	
Coal, Lower? Verne		9″	145′	7″	at 438 A. T.
Fire clay	4′	3″	149′	10″	
Sandy shale	38′		187′	10″	
Sandrock	4′		191′	10″	

TEST HOLE NO. 95.

In the S. W. ¼ of the N. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 595.′

Sand	2′		2′		
Sandy clay	62′		64′		
Hardpan	16′		80′		
Shale	16′		96′		
Black slate	17′	6″	113′	6″	
Coal, Upper Rider	1′		114′	6″	at 481 A. T.
Slate		6″	115′		
Light shale	3′		118′		
Coal, Upper Verne Main Rider	1′		119′		at 476 A. T.
Fire clay	4′		123′		
Black slate	15′		138′		
Coal, Upper Verne	3′		141′		at 454 A. T.
Fire clay	6′		147′		
Gray shale	7′		154′		

TEST HOLE NO. 96.

In the S. W. ¼ of the N. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 598.′

Sand	6′	6′	
Sandy clay	59′	65′	
Hardpan	30′	95′	
Shale	12′	107′	

Coal	Riders of Upper Verne	1′		108′		at 490 A. T.
Fire clay		3′		111′		
Coal		1′	6″	112′	6″	at 486 A. T.
Fire clay		6′		118′	6″	
Coal			6″	119′		at 479 A. T.
Fire clay		4′		123′		
Black slate		4′	6″	127′	6″	
Coal, Upper Verne		3′		130′	6″	at 468 A. T.
Fire clay		3′		133′	6″	

TEST HOLE NO. 97.

In the S. E. ¼ of the N. W. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 595.′

Sand	10′		10′		
Clay	50′		60′		
Sandy clay	20′		80′		
Hard gravel	43′		123′		
Fire clay	2′		125′		
Black slate	20′		145′		
Coal, Lower Verne	3′	1″	148′	1″	at 447 A. T.
Black slate		5″	148′	6″	
Fire clay	1′	6″	150′		
Dark shale	22′		172′		
Coal, Middle? Rider	2′		174′		at 421 A. T.
Sandy fire clay	8′		182′		
Sandy shale	14′		196′		

TEST HOLE NO. 98.

In the S. W. ¼ of the N. E. ¼ of Section 2, T. 13 N., R. 4 E., the elevation above tide is 594.′

Sand and gravel	18′		18′		
Clay	40′		58′		
Gravel	20′		78′		
Fire clay	4′		82′		
Sandrock	4′		86′		
Coal		4″	86′	4″	at 508 A. T.
Black slate	1′	8″	88′		
Salzburg coal		8″	88′	8″	at 505 A. T.
Sandy fire clay	7′	4″	96′		
Black slate	3′		99′		
Coal, Upper Rider	1′		100′		at 494 A. T.
Sandy fire clay	4′		104′		
Dark gray shale	16′		120′		
Coal, Upper Verne	2′	10″	122′	10″	at 471 A. T.
Black slate		2″	123′		
Fire clay	4′		127′		
Black slate	4′		131′		
Gray shale	19′		150′		
Black slate		6″	150′	6″	
Coal, Lower Verne	1′		151′	6″	at 443 A. T.
Black slate	1′		152′	6″	
Fire clay	3′	6″	156′		
Gray shale	10′		166′		
Sandy shale	20′		186′		
Sandrock	1′		187′		

TEST HOLE NO. 99.

In the S. E. ¼ of the N. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 593.′

Sandy clay	34′		34′	
Sand and gravel	13′		47′	
Clay	46′		93′	
Dark gray shale	16′		109′	
Coal, Upper Rider	3′	4″	112′	4″ at 481 A. T.
Black slate		8″	113′	
Sandy shale	24′		137′	
Coal, Upper Verne		6″	137′	6″ at 456 A. T.
Black slate	2′	6″	140′	
Dark gray shales	9′		149′	
Sandy shale	21′		170′	

TEST HOLE NO. 100.

In the N. E. ¼ of the N. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 594.′

Gravel	15′		15′	
Clay	45′		60′	
Gravel	19′		79′	
Fire clay	6′		85′	
Sandrock	10′		95′	
Dark shale	15′		110′	
Black slate	13′		123′	
Coal, Upper Verne	3′	4″	126′	4″ at 468 A. T.
Fire clay	1′	8″	128′	

TEST HOLE NO. 101.

In the N. W. ¼ of the N. E. ¼ of Section 2, T. 13 N., R. 4. E, elevation above tide is 595.′

Clay	80′		80′	
Gravel	24′		104′	
Dark gray shale	16′		120′	
Black slate	5′		125′	
Coal at 128½′, Upper Verne	3′	4″	128′	4″ at 467 A. T.
Sandy fire clay	1′	8″	130′	

TEST HOLE NO. 102.

In the N. W. ¼ of the N. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 596.′

Sandy clay	60′		60′	
Clay	41′		101′	
Fire clay	10′		111′	
Dark shale	15′		126′	
Black slate	9′	6″	135′	6″
Coal, Upper Verne	3′	4″	138′	10″ at 457 A. T.
Fire clay	2′	2″	141′	

TEST HOLE NO. 103.

In the N. E. ¼ of the N. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 590.′

Clay	55′		55′	
Sandy clay	51′		106′	
Sandy fire clay	6′		112′	
Dark gray shale	24′		136′	
Coal, Upper Verne	1′	8″	137′	8″ at 452 A. T.
Sandrock	10′	4″	148′	

TEST HOLE NO. 104.

In the S. E. ¼ of the S. W. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 581.′

Clay	68′		68′		
Slate	2′	6″	70′	6″	
Salzburg coal	2′	9″	73′	3″	at 508 A. T.
Slate	43′	9″	117′		

TEST HOLE NO. 105.

In the S. W. ¼ of the S. E. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 586.′

Sandy clay	77′		77′		
Black slate	11′		88′		
Salzburg coal	1′	3″	89′	3″	at 497 A. T.
Fire clay	3′	9″	93′		
Black slate	8′		101′		
Coal, Upper Rider	1′		102′		at 484 A. T.
Fire clay	3′		105′		
Dark slate	20′		125′		
Coal, Upper Verne	2′	2″	127′	2″	at 459 A. T.
Fire clay	3′		130′	2″	

TEST HOLE NO. 106.

In the S. W. ¼ of the S. E. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 585.′

Sandy clay		77′		77′		
Gravel		5′		82′		
Dark shale		18′		100′		
Black slate		4′		104′		
Coal	Riders of Upper Verne	2′		106′		at 479 A. T.
Fire clay		2′		108′		
Gray shale		5′		113′		
Coal		1′		114′		at 471 A. T.
Fire clay		2′		116′		
Coal		1′	8″	117′	8″	at 467 A. T.
Fire clay		1′	4″	119′		
Black slate		6′		125′		
Coal, Upper Verne		2′	6″	127′	6″	at 458 A. T.
Slate			6″	128′		

TEST HOLE NO. 107.

In the S. W. ¼ of the S. E. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 589.′

Clay	78′	6″	78′	6″	
Shale	26′	4″	104′	10″	
Coal	2′	2″	107′		at 482 A. T.
Slate	3′		110′		
Coal, Upper Rider	1′	10.5″	111′	10.5″	at 477 A. T.
Clay	2′	5″	114′	3″	
Slate	2′	10″	117′	1″	
Coal, Upper Verne?		5″	117′	6″	at 472 A. T.
Clay and slate	8′	5″	125′	11″	

TEST HOLE NO. 108.

In the N. E. ¼ of the S. W. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 584.37.'

Clay	74'	8"	74'	8"	
Slate	2'	4"	77'	3"	
Saltsburg coal	2'	9"	80'		at 504 A. T.
Shale	71'		151'		

TEST HOLE NO. 109.

In the S. W. ¼ of the N. E. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 590.'

Clay	82'		82'		
Blue shale	4'		86'		
Black sandrock	5'		91'		
Saltsburg coal		2"	91'	2"	at 499 A. T.
Black sandrock	1'	10"	93'		
White sandrock	4		97'		
Gray rock	3		100'		
Black slate	2	10"	102'	10"	
Coal		2"	103'		at 487 A. T.
Black slate	1'	2"	104'	2"	
Coal	1'	10"	106'		at 484 A. T.
Gray rock	1'	8"	107'	8"	
Fire clay	1'	8"	109'		
Gray slate	1'	8"	111'	8"	
Coal, Upper Bakers	1'	8"	113'	8"	at 476 A. T.
Fire clay	1'	8"	114'	4"	
Coal		11"	115'	3"	at 476 A. T.
Gray rock	4'	8"	119'	4"	
Coal	1'	11"	121'	3"	at 471 A. T.
Gray rock	1'	9"	122'	11"	
Coal, Upper Verne	1'	11"	124'	10"	at 459 A. T.
Fire clay	1'	11"	126'	9"	
Gray shale	16'	4"	142'	1"	
Gray rock	8		150'	1"	

TEST HOLE NO. 110.

In the N. W. ¼ of the S. E. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 589.

Clay	8'		8'		
Slate and rock	1'		119'		
Coal, Upper Bakers		8"	119'	8"	at 469 A. T.
Clay and rock	71'	4"	191'		

TEST HOLE NO. 111.

In the N. W. ¼ of the S. E. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 589.

Clay	7'		7'		
Slate	1'		108'		
Coal, Upper Bakers		8"	108'	8"	at 480 A. T.
Clay and rock	81'	4"	190'		

TEST HOLE NO. 112.

In the N. W. ¼ of the S. E. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 589.

Clay	7'		7'		
Coal		1"	7'	1"	at 480 A. T.
Slate	1'	11"	9'		
Coal, Upper Bakers	1'	11"	11'		at 480 A. T.
Rock	61'		122'		
Coal, Upper Verne	1'	11"	124'		at 463 A. T.

TEST HOLE NO. 112.

In the N. W. ¼ of the N. E. ¼ of Section 36, T. 14 N., R. 4 E., elevation above tide is 594.′

Sandy clay	26′		26′		
Clay	54′		80′		
Gravelly clay	11′		91′		
Clay	10′		101′		
Sandy clay	8′		109′		
Soapstone	2′		111′		
Gray rock	3′		114′		
Coal, Upper Rider	2′	3″	116′	3″	at 478 A. T.
Gray rock	4′	6″	120′	9″	
Coal	1′	10″	122′	7″	at 471 A. T.
Gray rock	2′	5″	125′		
White sandrock	7′	7″	132′	7″	
Coal, Upper Verne		4″	132′	11″	at 461 A. T.
Light gray rock	7′	6″	140′	5″	

TEST HOLE NO. 113.

In the S. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation 592 A. T.′

Clay	64′		64′		
Black slate	4′		68′		
Gray shale	22′		90′		
Black slate	1′		91′		
Coal	....		....		
Fire clay	6′		97′		
Dark gray shale	12′		109′		
Coal, Upper Rider	1′		110′		at 482 A. T.
Sandy fire clay	3′		113′		
Sandy shale	9′		122′		
Black slate		6″	122′	6″	
Coal, Upper Verne	1′	3″	123′	9″	at 468 A. T.
Gray sandrock	8′	3″	132′		
Black slate	16′	6″	148′	6″	
Coal, Lower Verne	2′	6″	151′		at 441 A. T.
Black slate		6″	151′	6″	

TEST HOLE NO. 114.

In the N. W. ¼ of the S. W. ¼ of Section 11, T. 13 N., R. 4 E., elevation above tide is 595.′

Clay	52′		52′		
Sand and gravel	44′		96′		
Gray shale	24′		120′		
Coal, Upper Rider	1′		121′		at 474 A. T.
Fire clay	2′		123′		
Gray shale	11′	6″	134′	6″	
Coal, Upper Verne		6″	135′		at 460 A. T.
Fire clay	2′		137′		
White sandrock	66′		203′		
Coal	....		....		
Fire clay	4′		207′		
White sandrock	8′		215′		

TEST HOLE NO. 115.

In the N. E. ¼ of the N. W. ¼ of Section 11, T. 13 N. R 4 E., elevation above tide is 584.′

Sandy clay	80′		80′		
Sand and gravel	28′		108′		
Gray shale	10′		118′		
Coal, Upper Rider		6″	118′	6″	at 466 A. T.
Gray shale	16′		134′	6″	
Coal, Upper Verne		8″	135′	2″	at 449 A. T.
Sandy shale	23′		158′	2″	
Coal, Lower Verne		6″	158′	8″	at 425 A. T.
Fire clay	2′	4″	161′		
Sandy shale	23′		184′		
Coal, Middle Rider		6″	184′	6″	400 at A. T.
Fire clay	2′	4″	186′	10″	
Sandy clay	54′		240′	10″	

TEST HOLE NO. 116.

In the S. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 580.′

Sand and gravel	12′		12′		
Clay	42′		54′		
Hardpan	10′		64′		
Black slate	10′		74′		
Gray shale	32′		106′		
Sandy shale	18′		124′		
Coal, Upper Verne	2′		126′		at 454 A. T.
Fire clay	4′		130′		
Gray shale	22′		152′		
Coal, Lower Verne	1′	8″	153′	8″	at 426 A. T.
Fire clay	3′	4″	157′		
Dark gray shale	15′		172′		
Gray rock	5′		177′		
Coal, Saginaw Coal?	1′	8″	178′	8″	at 401 A. T.
Fire clay	2′	4″	181′		
Black slate	29′		210′		
Coal, Lower Rider		6″	210′	6″	at 370 A. T.
Slate and coal	2′	3″	212′	9″	
Coal, Lower Coal	2′	3″	215′		at 365 A. T.
Fire clay	2′		217′		

TEST HOLE NO. 117.

In the S. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 580.′

Sandy clay	30′		30′		
Clay	48′		78′		
Sandy shale	16′		94′		
Black slate	1′		95′		
Coal, Upper Rider		6″	95′	6″	at 485 A. T.
Fire clay	6′	6″	102′		
Gray shale	19′		121′		
Black slate	6′		127′		
Coal, Upper Verne	2′	11″	129′	11″	at 450 A. T.
Fire clay	4′	1″	134′		
Sandrock	28′		162′		
Coal, Lower Verne	1′		163′		at 417 A. T.
Sandy shale	30′		193′		
Sandrock	6′		199′		

Coal Holes Near Michigan Standard Mine. From Mr. Etzold. In Monitor Township.

Test Holes Nos. 118-124.

TEST HOLE NO. 118.

In the S. W. ¼ of the N. W. ¼ of Section 25, T. 14 N., R. 4 E., elevation above tide is 597.′

Clay	76′		76′		
Hardpan	15′		91′		
Sandrock	2′		93′		
Slate	10′		103′		
Coal, Upper Verne	2′	1″	105′	1″	at 491 A. T.
Shale	1′		106′	1″	
Fire clay	2′	6″	108′	7″	
Slate	2′	9″	111′	4″	
Coal, Lower Verne	2′		113′	4″	at 484 A. T.
Fire clay	21′		134′	4″	
Shale	2′		136′	4″	
Fire clay	10′	6″	146′	10″	
Sandrock	23′	9″	177′		

TEST HOLE NO. 119.

In the W. ½ of the W. ½ of the E. ½ of the S. W. ¼ of Section 25, T. 14 N., R. 4 E., elevation above tide is 597.′

Clay	68′		68′	
Hardpan	12′		80′	
Gravel	8′		88′	
Hardpan	6′		94′	
Fine gravel	4′		98′	
Hardpan	7′		105′	
Fire clay	3′		115′	
Blue shale	1′		116′	
Gray sandrock and fire clay	19′	6″	135′	6″

TEST HOLE NO. 120.

In the W. ½ of the W. ½ of the E. ½ of the S. W. ¼ of Section 25, in Monitor township, T. 14 N., R. 4 E., elevation above tide is 597.′

Clay	73′		73′		
Hardpan	27′		100′		
Slate	7′		107′		
Coal, Upper Verne	1′	3″	108′	3″	at 489 A. T.
Slate	22′		130′	3″	
Fire clay	12′		142′	3″	

TEST HOLE NO. 121.

In the N. W. ¼ of the S. W. ¼ of Section 30, T. 14 N., R. 5 E., elevation above tide is 595.′

Clay	80′		80′	
Hardpan	2′		82′	
Sand and gravel	9′		91′	
Hardpan	2′		93′	
Slate	20′	2″	113′	2″
Fire clay	1′		114′	2″

Coal, Upper Verne		2″	114′	4″	at 481 A. T.
Fire clay	2′		116′	4″	
Fire clay	13′	8″	130′		
Slate	7′	1″	137′	1″	
Coal, Lower Verne	1′	8″	158′	9″	at 436 A. T.
Fire clay	2′		160′	9″	

TEST HOLE NO. 122.

In the N. ½ of the S. E. ¼ of Section 25, T. 14 N., R. 4 E., elevation above tide is 596.′

Clay	72′		72′		
Hardpan	10′		82′		
Shale	9′		91′		
Extra hard (Carbonate of Iron)	3′		94′		
Shale and slate	12′	6″	106′	6″	
Coal, Upper Verne	2′	6″	109′		at 487 A. T.
Shale and slate	9′	7″	118′	7″	
Coal, Lower Verne	3′	9″	122′	4″	at 474 A. T.
Fire clay		3″	122′	7″	

TEST HOLE NO. 123.

Near the S. W. corner of the N. W. ¼ of Section 30, T. 14 N., R. 5 E., elevation above tide is 596.′

To rock	97′		97′		
Rock	20′		117′		
Coal, Upper Verne	3′	3″	120′	3″	at 476 A. T.

TEST HOLE NO. 124.

In the E. ½ of the S. W. ¼ of Section 25, Monitor township, T. 14 N., R. 4 E., elevation above tide is 596.′

To rock	95′		95′		
Rock	20′		115′		
Coal, Upper Verne	3′		118′		at 478 A. T.
Slate	2′	9″	120′	9′	
Coal, Lower Verne	1′	11″	122′	8″	at 473 A. T.

Records from Mr. Chas. Coryell.

Test Holes Nos. 125-148.

TEST HOLE NO. 125.

In the S. E. ¼ of the S. E. ¼ of Section 25, T. 14 N., R. 4 E., elevation above tide is 594.′

Clay	78′		78′		
Hardpan	20′		98′		
Shale	6′		104′		
Seam of coal in shale	....		....		
Sandrock	8′	6″	112′	6″	
Black slate	5′		117′	6″	
Coal, Upper Verne	2′	11″	120′	5″	at 477 A. T.
Shale		6″	120′	11″	
Fire clay	....		....		

TEST HOLE NO. 126.

In the S. E. ¼ of the S. E. ¼ of Section 25, T. 14 N., R. 4 E., elevation above tide is 594.′

Clay	77′	77′	
Hardpan	22′	99′	
Shale and coal seam	7′	106′	
Sandrock	8′ 6″	114′ 6″	
Black slate	4′	118′ 6″	
Coal, Upper Verne	2′ 10″	121′ 4″	at 473 A. T.
Fire clay	5″	121′ 9″	

TEST HOLE NO. 127.

In the S. E. ¼ of the S. E. ¼ of Section 25, T. 14 N., R. 4 E., elevation above tide is 594.′

Clay	78′	78′	
Hardpan	31′	109′	
Shale	3′ 4″	112′ 4″	
Coal, Upper Verne	2′ 8″	115′	at 479 A. T.
Sandrock	11′	126′	
Black slate	7′	133′	
Coal, Lower Verne	3′ 9″	136′ 9″	at 457 A. T.

TEST HOLE NO. 128.

In the S. E. ¼ of the S. E. ¼ of Section 25, T. 14 N., R. 4 E., elevation above tide is 594.′

Top of rock	108′	108′	
Shale	6′	114′	
Fire clay	2′	116′	
Sand rock	6′	122′	
Slate	6′	128′	
Coal, Lower Verne	2′ 10″	130′ 10″	at 463 A. T.

TEST HOLE NO. 129.

In the S. W. ¼ of the S. E. ¼ of Section 30, T. 14 N., R. 5 E., elevation above tide is 590.′

Drift	86′	86′	
Coal, Lower Verne	3′	145′ 4″	at 445 A. T.

TEST HOLE NO. 130.

In the N. ½ of the N. W. ¼ of Section 31, T. 14 N., R. 5 E., elevation above tide is 593.′

Drift	85′	
Depth of hole	142′	
Coal thickness, Lower Verne	2′ 10″	at 453 A. T.

TEST HOLE NO. 131.

In the N. ½ of the N. W. ¼ of Section 31, T. 14 N., R. 5 E., elevation above tide is 593.′

Surface	80′	
Depth of hole	140′	
Coal, Lower Verne	2′ 8″	at 453 A. T.

TEST HOLE NO. 132.

City limits of West Bay City and 23d St. In the S. E. corner of Section 30, Monitor township, T. 14 N., R. 5 E., elevation above tide is 590.′

Clay	74′		74′		
Hardpan	2′		76′		
Black shale	8′		84′		
Black sandy slate	2′	3″	86′	3″	
Salzburg coal	5′		91′	3″	at 499 A. T.
Fire clay	8′		99′	3″	
Coal, Upper Rider		6″	99′	9″	at 490 A. T.
Fire clay	37′	9″	137′	6″	

TEST HOLE NO. 133.

In the S. E. part of Section 30, T. 14 N., R. 5 E., elevation above tide is 589.′

Clay	74′		74′		
Hardpan	2′		76′		
Blue shale	8′		84′		
Sandy slate	2′	3″	86′	3″	
Salzburg coal	5′	3″	91′	6″	at 498 A. T.
Fire clay	8′		99′	6″	
Coal, Upper Rider		6″	100′		at 489 A. T.
Fire clay	92′	3″	192′	3″	

TEST HOLE NO. 134.

In the S. W. part of Section 29, T. 14 N., R. 5 E., elevation above tide is 589.′

Clay	76′		76′		
Hardpan	6′		82′		
Slate	8′		90′		
Salzburg coal	4′	9″	94′	9″	at 494 A. T.
Shale		6″	95′	3″	
Fire clay	5′	6″	100′	9″	

TEST HOLE NO. 135.

West Bay City, S. W. part of Section 29, T. 14 N., R. 5 E., elevation above tide is 589.′

Clay	72′		72′		
Hardpan	6′		78′		
Salzburg Coal Rider		6″	78′	6″	at 511 A. T.
Shale		6″	79′		
Fire clay	6′		85′		
Shale	3′	6″	88′	6″	
Salzburg coal		6″	89′		at 500 A. T.
Fire clay	21′	3″	110′	3″	

TEST HOLE NO. 136.

Inside of limits of West Bay City. S. W. corner of Section 29, T. 14 N., R. 5 E., elevation above tide is 590.′

Clay	79′	10″	79′	10″	
Hardpan	6′	2″	86′		
Blue shale	4′		90′		
Hard sand slate	3′		93′		
Slate and bone coal	2′	4″	95′	4″	
Salzburg coal	3′	2″	98′	6″	at 492 A. T.
Shale		6″	99′		
Fire clay	23′		122′		

TEST HOLE NO. 137.

Inside limits of West Bay City. S. W. corner of Section 29, T. 14 N., R. 5 E., elevation above tide is 590.′

Clay	80′		80′	
Hardpan	11′		91′	
Salzburg coal	1′	3″	92′	3″ at 498 A. T.
Shale		6″	92′	9″
Fire clay	19′	10″	112′	7″

TEST HOLE NO. 138.

In the S. W. corner of Section 29, T. 14 N., R. 5 E., elevation above tide is 590.′

Clay	76′		76′	
Hardpan and gravel mixed with coal.	23′		99′	
Fire clay	23′	7″	122′	7″

TEST HOLE NO. 139.

Near the N. E. corner of Section 31, T. 14 N., R. 5 E., elevation above tide is 590.′

Clay	81′		81′	
Hardpan, none.				
Slate	9′		90′	
Salzburg coal	3′		93′	at 497 A. T.
Soft shale		6″	93′	6″
Fire clay	1′	6″	95′	

TEST HOLE NO. 140.

Hole commenced Saturday, May 6th, and finished Monday, May 8th. Near the N. E. corner of Section 31, T. 14 N., R. 5 E., the elevation above tide is 590.′

Clay	81′		81′	
Hardpan, none.				
Slate	9′		90′	
Salzburg coal	3′		93′	at 497 A. T.
Soft shale		6″	93′	6″
Fire clay	1′	6″	95′	

TEST HOLE NO. 141.

Commenced Tuesday, May 9, and finished Wednesday, May 10th, 1899. In the N. E. ¼ of the N. E. ¼ of Section 31, T. 14 N., R. 5 E., elevation above tide is 585.′

Clay	81′	6″	81′	6″
Hardpan	....		....	
Slate	8′	6″	90′	
Salzburg coal	3′		93′	at 492 A. T.
Soft shale		4″	93′	4″

TEST HOLE NO. 142.

Commenced May 11, finished May 12, 1899. In the S. E. ¼ of the S. E. ¼ of Section 30, T. 14 N., R. 5 E., elevation above tide is 585.′

Clay	75′		75′	
Hardpan	7′		82′	
Light shale	4′		86′	
Dark shale	3′	4″	89′	4″

Salzburg coal		8″	90′		at 495 A. T.
Light shale	3′		93′		
Dark shale	6′	2″	99′	2″	
Coal, Upper Rider	3′		102′	2″	at 483 A. T.
Fire clay	2′	6″	104′	8″	

TEST HOLE NO. 143.

Commenced May 13, ended May 21, 1899, In the S. E. ¼ of the S. E. ¼ of Section 30, T. 14 N., R. 5 E., elevation above tide is 590.′

Clay	76′		76′		
Hardpan and gravel	21′		97′		
Fire clay	3′		100′		
Slate	6′	9″	106′	9″	
Coal, Upper Verne	3′		109′	9″	at 480 A. T.
Shale		6″	110′	3″	
Fire clay and sandrock	48′	9″	159′		

TEST HOLE NO. 144.

Commenced May 22, finished May 24, 1899. In the S. E. ¼ of the S. E. ¼ of Section 30, T. 14 N., R. 5 E., elevation above tide is 590.′

Clay	68′	4″	68′	4″	
Hardpan	6′	2″	74′	6″	
Slate	8′		82′	6″	
Salzburg coal	4′	9″	87′	3″	at 503 A. T.
Shale		9″	87′	9″	
Fire clay	1′		88′	9″	

TEST HOLE NO. 145.

In the N. E. ¼ of the S. E. ¼ of Section 30, T. 14 N., R. 5 E., elevation above tide is 590.′

Clay	80′		80′		
Hardpan	11′		91′		
Slate, very black	10′	6″	101′	6″	
Coal		3″	101′	9″	at 488 A. T.
Light slate	14′	10″	116′	7″	
Coal, Upper Rider	1′	8″	118′	3″	at 472 A. T.
Light sandy slate	3′	10″	122′	1″	
Coal, Upper Verne	2′	6″	124′	7″	at 465 A. T.
Shale	1′		125′	7″	
Fire clay		6″	126′	1″	

TEST HOLE NO. 146.

In the N. E. ¼ of the S. E. ¼ of Section 30, T. 14 N., R. 5 E., elevation above tide is 595.′

Clay	76′		76′		
Hardpan	20′		96′		
Slate, black	15′		111′		
Coal seam	....		....		at 484 A. T.
Light slate	11′		122′		
Black slate	2′	7″	124′	7″	
Coal, Upper Rider		8″	125′	3″	at 470 A. T.
Light slate	6′	3″	131′	6″	
Black slate	4′	2″	135′	8″	
Coal, Lower Verne	4′	7″	140′	3′	at 455 A. T.

TEST HOLE NO. 147.

In the N. E. ¼ of the S. E. ¼ of Section 30, T. 14 N., R. 5 E., elevation above tide is 595.′

Clay	78′		78′		
Hardpan	21′		99′		
Slate	14′		113′		
Light shale	10′	6″	123′	6″	
Slate	1′		124′	6″	
Coal, Upper Verne	1′	3″	125′	9″	at 469 A. T.
Slate	10′		135′	9″	
Coal, Lower Verne	3′	4″	139′	1″	at 456 A. T.
Fire clay	3′	2″	142′	3″	
Slate	17′	3″	159′	6″	
Coal, Middle Rider	2′	10″	162′	4″	at 433 A. T.
Fire clay	2′		164′	4″	

TEST HOLE NO. 148.

In the N. E. ¼ of the N. W. ¼ of Section 11, T. 14 N., R. 5 E., elevation above tide is 610.′

Drift	110′		110′		
Light slate	77′		187′		
Sandrock	38′	10″	225′	10″	

Records in Monitor Township. Leonard Zill and John S. Wuepper, drillers.

Test Holes No's 149-172.

TEST HOLE NO. 149.

In the S. W. ¼ of the N. W. ¼ of Section 20, T. 14 N., R. 4 E., elevation above tide is 604.′

Clay	50′		50′		
Sand and gravel	50′		100′		
Hardpan	15′		115′		
Slate	22′		137′		
Black slate	3′		140′		
Coal, Upper Verne		2″	140′	2″	at 464 A. T.
Light slate	33′		173′	2″	
Black slate	1′		174′	2″	
Light slate	4′		178′	2″	
Fire clay and sandrock	5′		183′	2″	

TEST HOLE NO. 150.

In the center of the S. W. ¼ of the S. W. ¼ of Section 5, T. 14 N., R. 4 E., elevation above tide is 612.′

Clay	82′		82′		
Sand and gravel	24′		106′		
Clay	4′		110′		
Fire clay	10′		120′		
Light slate	12′		132′		
Black slate	4′	2″	136′	2″	
Fire clay	2′		138′	2″	
Black slate	1′	8″	139′	10″	
Coal, Upper Verne		4″	140′	2″	at 472 A. T.
Light slate	6′		146′	2″	
Sandrock	4′		150′	2″	

Light slate	5′		155′	2″	
Sandrock	23′		178′	2″	
Light slate	3′		181′	2″	
Sandrock	7′		188′	2″	

TEST HOLE NO. 151.

In the E. ½ of the S. E. ¼ of Section 17, T. 14 N., R. 4 E., elevation above tide is 600.′

Clay	58′		58′		
Sandstone	66?′		124′		
Slate	67′	6″	191′	6″	
Fire clay	2′	6″	194′		
Slate	12′	9″	206′	9″	
Coal, Saginaw coal		8″	207′	5″	at 393 A. T.
Fire clay	2′	6″	209′	11″	
Slate	3′		212′	11″	
Slate and fire clay	11′	7″	224′	6″	
Black slate	17′		241′	6″	
Coal, Lower coal	2′	10″	244′	4″	at 356 A. T.
Slate and sandrock	42′		286′	4″	
Black slate		6″	286′	10″	
Sandrock	6′		292′	10″	

TEST HOLE NO. 152.

In the N. part of the S. E. ¼ of the S. E. ¼ of Section 17, T. 14 N., R. 4 E., elevation above tide is 595.′

Clay	64′		64′		
Sand	2′		66′		
Soapstone	2′		68′		
Gravel	20′	3″	88′	3″	
Slate	13′	5″	101′	8″	
Fire clay	3′		104′	8″	
Slate	2′		106′	8″	
Coal, Upper Rider		2″	106′	10″	at 488 A. T.
White slate	8′		114′	10″	
Black slate	12′		126′	10″	
Coal, Upper Verne	3′	3″	130′	1″	at 465 A. T.
Fire clay	....		....		

TEST HOLE NO. 153.

Near Wolverine shaft No. 2, T. 14 N., R. 4 E., elevation above tide 618 feet.

Clay	58′		58′		
Hardpan	20′	6″	78′	6″	
Salzburg coal Rider		6″	79′		at 539 A. T.
Fire clay	1′		80′		
Sandrock		8″	80′	8″	
Slate	8′		88′	8″	
Salzburg coal	1′	6″	90′	2″	at 528 A. T.
Fire clay	7′		97′	2″	
Coal		8″	97′	10″	
Slate	6′		103′	10″	
Fire clay	2′	2″	106′		
Slate		6″	106′	6″	
Coal, Upper Rider		8″	107′	2″	at 511 A. T.
Light slate	14′		121′	2″	
Black slate	7′	1″	128′	3″	
Coal, Upper Verne	2′	7.5″	130′	10½″	at 487 A. T.
Fire clay	4′		134′	10½″	

TEST HOLE NO. 154.

At the N. end of N. and S. $\frac{1}{8}$ line of S. E. $\frac{1}{4}$ of Section 17, T. 14 N., R. 4 E., elevation above tide is 595.′

Clay	60′		60′	
Gravel	10′		70′	
Hardpan	9′		79′	
Salzburg coal	2′	3″	81′	3″ at 514 A. T.
Fire clay	10′	6″	91′	9″
Slate	8′	4″	100′	1″
Fire clay	1′		101′	1″
Slate	1′		102′	1″
Fire clay	4′		106′	1″
Light slate	10′		116′	1″
Black slate	14′	6″	130′	7″
Coal, Upper Verne	2′	9″	133′	4″ at 462 A. T.
Fire clay	....		....	

TEST HOLE NO. 155.

In the N. W. $\frac{1}{4}$ of the S. E. $\frac{1}{4}$ of Section 17, T. 14 N., R. 4 E. This is 50 feet northwest of Wolverine shaft number 2. Elevation above tide is 619.′

Clay	75′		75′	
Hardpan	14′		89′	
Slate	16′	10″	105′	10″
Salzburg coal		2″	106′	at 513 A. T.
Fire clay	1′		107′	
Slate	2′		109′	
Coal, Upper Rider		4″	109′	4″ at 510 A. T.
Slate	43′	8″	153′	
Coal, Upper Verne	4′	8.5″	157′	8½″ at 461 A. T.
Slate	1′		158′	8½″

Alternating with fire clay, March, 1900.

TEST HOLE NO. 156.

N. W. corner of S. E. $\frac{1}{4}$ of the N. E. $\frac{1}{4}$ of Section 17, elevation above tide is 600.′ T. 14 N., R. 4 E.

Clay	64′		64′	
Hardpan	10′		74′	
Coal	4′		78′	at 522 A. T.
Fire clay	2′		80′	
Slate	16′		96′	
Salzburg coal	1′	8″	97′	8″ at 502 A. T.
Fire clay	2′	4″	100′	
Slate	23′		123′	
Coal, Upper Verne	2′	8″	125′	8″ at 474 A. T.
Fire clay	....		....	

TEST HOLE NO. 157.

Center of S. E. $\frac{1}{4}$ of the S. W. $\frac{1}{4}$ of Section 17, T. 14 N., R. 4 E., elevation above tide is 603.′

Clay	35′		35′	
Sand	3′	6″	38′	6″
Clay	20′		58′	6″
Sand	20′		78′	6″
Hardpan	56′		134′	6″
Fire clay	15′		149′	6″
Gray rock	39′		188′	6″

TEST HOLE NO. 158.

In the N. W. ¼ of the S. E. ¼ of Section 17, T. 14 N., R. 4 E., elevation above tide is 615.′

Clay	70′		70′	
Hardpan	17′		87′	
Clay	5′		92′	
Hardpan	4′		96′	
Coal	....		....	at 519 A. T.
Fire clay	2′		98′	
Slate	28′	5″	126′	5″
Coal, Upper Rider	3′	6½″	129′	11½″ at 485 A. T.
Fire clay	3′		132′	11½″

TEST HOLE NO. 159.

In the N. W. ¼ of the S. E. ¼ of Section 17, T. 14 N., R. 4 E., hole 800 feet southwest of shaft No. 2 of Wolverine Coal Company. Elevation above tide is 610.′

Clay	60′	60′	
Hardpan	30′	90′	
Sand	12′	102′	
Slate	14′	116′	
Fire clay	6′	122′	
Slate	16′	138′	
Coal, Upper Verne	2′	140′	at 470 A. T.
Fire clay	12′	152′	

TEST HOLE NO. 160.

On the center of the E. and W. ⅛ line of the S. E. ¼ of Section 17, T. 14 N., R. 4 E., elevation above tide is 610.′

Clay	66′	66′	
Hardpan	6′	72′	
Sandrock	2′	74′	
Slate	3′	77′	
Sandrock	4′	81′	
Slate	5′	86′	
Fire clay	2′	88′	
Slate	3′	91′	
Fire clay	1′	92′	
Slate	3′	95′	
Sandrock	4′	99′	
Slate	10′	109′	
Coal, Upper Rider	2′	111′	at 499 A. T.
Fire clay	2′	113′	

TEST HOLE NO. 161.

Just E. of the ⅛ line of the N. E. ¼ of the E. ½ of the S. E. ¼ in distance about ⅓ S. from the end of the N. line of the S. E. ¼ of Section 17, T. 14 N., R. 4. E., elevation above tide is 612.′

Clay	66′		66′	
Hardpan	18′		84′	
Coal		5″	84′	5″ at 528 A. T.
Fire clay	2′		86′	5″
Slate	1′	7″	88′	
Salzburg coal Rider		3″	88′	3″ at 524 A. T.
Fire clay	3′		91′	3″
Slate	7′	9″	99′	
Fire clay	1′	6″	100′	6″
Slate	9′	6″	110′	

Coal, Upper Rider	2″	110′ 2″	at 502 A. T.
Fire clay	1′ 10″	112′	
Slate	18′ 3″	130′ 3″	
Coal, Upper Verne	2′ 9″	133′	at 479 A. T.

TEST HOLE NO. 162.

In the N. W. ¼ of the S. E. ¼ of Section 17, T. 14 N., R. 4 E. Hole 600 feet due north of shaft. Elevation above tide is 615.′

Clay	70′	70′	
Hardpan	3′	73′	
Gravel	3′	76′	
Hardpan	2′	78′	
Gravel	1′	79′	
Clay	3′	82′	
Slate	18′	100′	
Coal	....	....	at 515 A. T.
Fire clay	4′	104′	
Black slate	32′	136′	
Coal, Upper Verne	3′ 4″	139′ 4″	at 476 A. T.
Fire clay and sandrock	28′	167′ 4″	

TEST HOLE NO. 163.

In the N. E. ¼ of the S. E. ¼ of Section 17, T. 14 N., R. 4 E., elevation above tide is 600.′

Clay	64′	64′	
Hardpan	7′ 6″	71′ 6″	
Slate	10′ 6″	82′	
(Coal)	....	....	at 518 A. T.
Fire clay	1′	83′	
Slate	1′ 6″	84′ 6″	
Fire clay	1′	85′ 6″	
Slate	6″	86′	
Salzburg coal	10″	86′ 10″	at 513 A. T.
Fire clay	3′ 2″	90′	
Sandrock	2′	92′	
Slate	20′	112′	
Coal, Upper Rider	2″	112′ 2″	at 488 A. T.
Fire clay	3′	115′ 2″	
Slate	19′ 3″	134′ 5″	
Coal, Upper Verne	3′ 4″	137′ 9″	at 463 A. T.

TEST HOLE NO. 164.

In the N. E. ¼ of the S. E. ¼ of Section 17, T. 14 N., R. 4 E., elevation above tide is 600.′

Clay	66′	66′	
Hardpan	10′	76′	
Gravel	5′	81′	
Slate	13′	94′	
Fire clay	3′	97′	
Slate	8′	105′	
Fire clay	3′	108′	
Coal, Upper Rider	2″	108′ 2″	at 492 A. T.
Slate	38′ 10″	147′	
Coal, Upper Verne?	4′ 3″	151′ 3″	at 449 A. T.

TEST HOLE NO. 165.

In the S. W. ¼ of the S. E. ¼ of Section 17, T. 14 N., R. 4 E., 100 feet east and 800 or 900 feet south of the Wolverine shaft No. 2. Elevation above tide is 605.′

Clay	60′		60′	
Sandrock?	15′		75′	
Clay	5′		80′	
Sand	10′		90′	
Slate	10′		100′	
Fire clay	4′		104′	
Slate	6′		110′	
Fire clay	3′		113′	
Slate	4′		117′	
Fire clay	3′		120′	
Slate	14′		134′	
Coal, Upper Verne	2′	6″	136′	6″ at 469 A. T.
Fire clay	2′		138′	6″

TEST HOLE NO. 166.

In the S. W. ¼ of the N. W. ¼ of Section 17, T. 14 N., R. 4 E., elevation above tide is 600.′

Clay	100′		100′	
Sand	50′		150′.	

TEST HOLE NO. 167.

In the N. W. corner of the E. ½ of the N. E. ¼ of Section 33, T. 14 N., R. 4 E. This is 60 rods east of old Monitor shaft, elevation above tide is 602.′

Clay	81′	5″	81′	5″
Rock	4′	8″	86′	1″
Salzburg coal Rider		6″	86′	7″ at 515 A. T.
Fire clay	5′	6″	92′	1″
Slate	7′	4″	99′	5″
Salzburg coal		4″	99′	9″ at 502 A. T.
Fire clay	3′		102′	9″
Rock		8″	103′	5″
Coal		2″	103′	7″ at 499 A. T.
Fire clay		11″	104′	6″
Slate	11′	6″	116′	
Coal		4″	116′	4″ at 486 A. T.
Slate	3′	6″	119′	10″
Coal, Upper Rider	1′	6″	121′	4″ at 481 A. T.
Fire clay	3′		124′	4″
Slate	2′	8″	127′	
Coal, Upper Verne	3′	2″	130′	2″ at 472 A. T.

TEST HOLE NO. 168.

In the N. E. corner of Section 33, T. 14 N., R. 4 E., elevation above tide is 602.′

Clay	38′	2″	38′	2″
Hardpan and gravel	29′		67′	2″
Cobbles	2′		69′	2″
Sand and gravel	30′	4″	99′	6″
Slate	6′		105′	6″
Salzburg coal		6″	106′	at 496 A. T.
Fire clay	3′	8″	109′	8″
Slate	2′	7″	112′	3″
Coal Rider		6″	112′	9″ at 489 A. T.

Fire clay	3′	6″	116′	3″	
Slate	2′	5″	118′	8″	
Coal, Upper Rider	2′	5″	121′	1″	at 481 A. T.
Fire clay and slate	19′	2″	140′	3″	

TEST HOLE NO. 169.

In the S. W. corner of the N. W. ¼ of the S. W. ¼ of Section 27, T. 14 N., R. 4. E., elevation above tide is 602.′

Black loam—muck	2′		2′		
Sand	3′		5′		
Clay and stone (gravel)	25′		30′		
Blue clay	6′		36′		
Sand	5′		41′		
Hardpan	4′		45′		
Sand	2′	6″	47′	6″	
Hardpan	24′		71′	6″	
Red soapstone	2′		73′	6″	
Gray soapstone	1′		74′	6″	
Slate	20′	3″	94′	9″	
Salzburg coal		5″	95′	2″	at 507 A. T.
Fire clay	2′	4″	97′	6″	
Slate	7′	6″	105′		
Coal Rider		3″	105′	3″	at 497 A. T.
Fire clay	3′	6″	108′	9″	
Slate	3′		111′	9″	
Black slate	9′	3″	121′		
Coal, Upper Rider	2′	4″	123′	4″	at 479 A. T.
Fire clay	5′	4″	128′	8″	

TEST HOLE NO. 170.

On the E. line at end of N. E. and W. ⅛ line of Section 33, T. 14 N., R. 4 W., elevation above tide is 601.′

Clay	28′	8″	28′	8″	
Hardpan and stone (Gr.)	62′		90′	8″	
Slate	2′		92′	8″	
Salzburg coal		10″	93′	6″	at 508 A. T.
Fire clay	3′	8″	97′	2″	
Sandrock	4′	2″	101′	4″	
Slate	4′	10″	106′	2″	
Coal	1′	5″	107′	7″	at 493 A. T.
Fire clay	3′		110′	7″	
Slate	2′	5″	113′		
Coal, Upper Rider	2′	8″	115′	8″	at 486 A. T.
Fire clay		4+″	116′		

TEST HOLE NO. 171.

In the N. E. ¼ of the N. E. ¼ of Section 33, T. 14 N., R. 4 E. This is Bay shaft number one, now abandoned. Elevation above tide is 602.′

Clay	84′	3″	84′	3″	
Rock	36′	3″	120′	6″	
Coal, Upper Rider	1′	6″	122′		at 480 A. T.
Fire clay	3′		125′		
Slate	7′	2″	132′	2″	
Coal, Upper Verne	3′	4″	135′	6″	at 467 A. T.
Fire clay	....		....		

TEST HOLE NO. 172.

In the center of the W. ½ of the S. E. ¼ af Section 29, T. 14 N., R. 4 E. elevation above tide is 611.′

Clay	50′	50′	
Hardpan	50′	100′	
Clay	5′	105′	
Sand	5′	110′	
Gravel	8′	118′	
Soapstone (white clay)	3′	121′	
Light slate	3′	124′	
(Coal), Upper Rider	....	....	at 487 A. T.
Fire clay	2′	126′	
Black slate	8′	134′	
"Draw" slate (½ slate and coal), Upper Verne	2′	136′	at 475 A. T.
Fire clay	1′	137′	
Light slate	14′	151′	
Fire clay	2′	153′	
Gray rock	7′	160′	
Light slate	2′	162′	
Sandrock	2′	164′	

Leonard Zill, West Bay City, Driller.

Test Holes No's 173-221.

TEST HOLE NO. 173.

In the N. W. ¼ Section 13, and W. 80 rod line, T. 13 N., R. 4 E., elevation above tide is 590.′

Sand	20′		20′		
Clay	74′	4″	94′	4″	
Sand	15′		109′	4″	
Black slate	14′		123′	4″	
Coal, Upper Verne	1′	1″	124′	5″	at 466 A. T.
Light slate	2′		126′	5″	
Fire clay	2′		128′	5″	
Light slate	3′		131′	5″	
Fire clay	7′	9″	139′	2″	
Light slate	2′		141′	2″	
Fire clay	3′		144′	2″	
Light slate	16′		160′	2″	
Black slate	3′		163′	2″	
Light slate	4′		167′	2″	
Sandrock	5′		172′	2″	

TEST HOLE NO. 174.

In the N. W. ¼ of the S. E. ¼ of Section 12, T. 13 N., R. 4 E., the elevation above tide is 584.′

Clay	68′	9″	68′	9″	
Sand	10′		78′	9″	
Gravel	2′		80′	9″	
Light slate	10′		90′	9″	
Black slate	3′		93′	9″	
Light slate	6′		99′	9″	
Gray rock	11′		110′	9″	
Sandrock	8′		118′	9″	
Fire clay	9′		127′	9″	
Sandrock	12′	7″	140′	4″	

TEST HOLE NO. 175.

In the N. E. ¼ of the N. W. ¼ of Section 5, T. 13 N., R. 4 E., the elevation above tide is 615.′

Clay	59′		59′		
Hardpan	19′		78′		
Sand	32′		110′		
Hardpan	5′		115′		
Sandrock	17′		132′		
Light slate	2′		134′		
Fire clay	2′		136′		
Sandrock	25′		161′		
Sandrock	4′	2″	165′	2″	

TEST HOLE NO. 176.

On the N. and S. 80 rod line, N. E. ¼ of Section 5, T. 13 N., R. 4 E., elevation above tide is 615.′

Clay	55′		55′		
Sand	12′		67′		
Hardpan	20′	4″	87′	4″	
Clay	10′		97′	4″	
Sand	26′	8″	124′		
Light slate	50′	4″	174′	4″	
Black slate	2′		176′	4″	

TEST HOLE NO. 177.

In the N. E. ¼ of Section 1, T. 13 N., R. 4 E. Near shaft of Valley Mine. elevation above tide is 584.′

Clay	78′	7″	78′	7″	
Hardpan	2′	2″	80′	9″	
Fire clay	2′		82′	9″	
Black slate	5′		87′	9″	
Salzburg coal		10″	88′	7″	at 495 A. T.
Light slate	1′	6″	90′	1″	
Fire clay	3′		93′	1″	
Black slate	19′		112′	1″	
Coal, Upper Verne	2′	9″	114′	10″	at 469 A. T.

TEST HOLE NO. 178.

In the W. ½ of the E. ½ of the S. W. ¼ of Section 33, T. 14 N., R. 4 E., the elevation above tide is 608.′

Clay	78′		78′		
Sand	26′		104′		
Sandrock	2′		106′		
Coal, Upper Rider		8″	106′	8″	at 501 A. T.
Fire clay	10′		116′	8″	
Gray rock	9′		125′	8″	
Slate	5′		130′	8″	
Coal, Upper Verne		8″	131′	4″	at 477 A. T.
Slate	20′		151′	4″	
Fire clay	4′		155′	4″	
Slate	21′		176′	4″	
Coal, Lower Verne		3″	176′	7″	at 431 A. T.
Black slate	5′	1″	181′	8″	
Coal, Middle Rider		6″	182′	2″	at 426 A. T.
Slate	7′		189′	2″	
Coal, Saginaw coal	1′	7″	190′	9″	at 417 A. T.
Fire clay	2′	4″	193′	1″	

TEST HOLE NO. 179.

In the N. E. ¼ of Section 1, T. 13 N., R. 4 E., elevation above tide is 584.′

Sand	18′	18′	
Clay	72′	90′	
Sand	35′	125′	
Clay	10′	135′	
Gravel	2′	137′	
Sand	10′	147′	
Clay	8′	155′	
Sand	4′	159′	
Gravel	2′	161′	

TEST HOLE NO. 180.

In the S. E. ¼ of the S. E. ¼ of Section 29, T. 14 N., R. 4 E., elevation above tide is 608.′

Clay	50′		50′	
Sand and gravel	50′		100′	
Hardpan	15′		115′	
Light slate	22′		137′	
Black slate	3′		140′	
Coal, Upper Verne	2′	2″	142′	2″ at 466 A. T.
Light slate	33′		175′	2″
Black slate	1′		176′	2″
Light slate	4′		180′	2″
Sandrock	5′		185′	2″

TEST HOLE NO. 181.

In the S. ½ of the S. E. ¼ of the N. E. ¼ of Section 16, T. 13 N., R. 4 E., the elevation above tide is 605.′

Clay	90′	90′
Hardpan	30′	120′
Sand	15′	135′
Gravel	5′	140′
Sand	8′	148′
Black slate	6′	154′
Gray rock	6′	160′
Black slate, horizon of Lower Verne	10′	170′
Fire clay	3′	173′
Gray rock	7′	180′
Light slate	15′	195′
Black slate	5′	200′
Sandrock	11′	211′
Black slate	3′	214′
Sandrock	2′	216′

TEST HOLE NO. 182.

In the S. E. ¼ of the S. W. ¼ of Section 16, T. 14 N., R. 4 E., elevation above tide is 600.′

Clay	44′	44′
Sand	3′	47′
Clay	8′	55′
Sand	22′	77′
Sandrock	3′	80′
Slate	2′	82′
Fire clay	6′	88′
Gray rock	3′	91′
Black slate	3′	94′
Fire clay	4′	98′
Sandrock	1′	99′

Black slate	1′	6″	100′	6″	
Fire clay	2′		102′	6″	
Gray rock	1′		103′	6″	
Black slate	10′		113′	6″	
Salzburg coal	2′		115′	6″	at 485 A. T.
Fire clay	1′	6″	117′		
Sandrock	16′		133′		
Coal, Upper Rider	2′	5″	135′	5″	at 465 A. T.
Fire clay	1′	4″	136′	9″	
Blue slate	5′		141′	9″	
Coal, Upper Verne	1′	7″	143′	4″	at 457 A. T.
Fire clay	1′		144′	4″	
Sandrock	10′		154′	4″	
Black slate	12′		166′	4″	
Coal, Lower Verne	1′	1″	167′	5″	at 433 A. T.
Fire clay	3′		170′	5″	
Blue slate	37′		207′	5″	
Sandrock	1′		208′	5″	
Fire clay	1′		209′	5″	

TEST HOLE NO. 183.

In the S. W. ¼ of the S. E. ¼ of Section 16, T. 14 N., R. 4 E., elevation above tide is 600.′

Clay	48′		48′		
Hardpan	20′		68′		
Sand	3′		71′		
Clay	6′		77′		
Sand	23′		100′		
Clay	3′		103′		
Sand	11′		114′		
Clay	7′		121′		
Fire clay	11′		132′		
Blue slate	18′	7″	150′	7″	
Coal, Lower Verne	4′	6″	155′	1″	at 445 A. T.
Gray rock	3′		158′	1″	

TEST HOLE NO. 184.

In the S. W. ¼ of the S. W. ¼ of Section 3, T. 13 N., R. 4 E., elevation above tide is 595.′

Clay	80′	80′	
Sand	20′	100′	
Hardpan	10′	110′	
Sand	80′	190′	

TEST HOLE NO. 185.

In the E. ½ of the S. E. ¼ of Section 33, T. 14 N., R. 4 E., elevation above tide is 600.′

Clay	70′		70′		
Gravel	2′		72′		
Clay	13′		85′		
Gravel	10′		95′		
Sand	2′		97′		
Sandrock	6′		103′		
Blue slate	1′		104′		
Coal, Upper Rider		9″	104′	9″	at 495 A. T.
Fire clay	3′		107′	9″	
Light slate	23′		130′	9″	
Blue slate	9′		139′	9″	
Coal, Rider of Lower Verne	2′	6″	142′	3″	at 458 A. T.
Gray rock	11′		153′		

Coal, Lower Verne		3.5″	153′	3.5″	at 447 A. T.
Sandrock	1′		154′	3.5″	
Blue slate	6′		160′	3.5″	
Sandrock	1′		161′	3.5″	

TEST HOLE NO. 186.

In the W. ½ of the N. W. ¼ of Section 3, T. 13 N., R. 4 E., elevation above tide is 600.′

Clay	76′		76′		
Sand	3′		79′		
Gravel	2′	6″	81′	6″	
Hardpan	8′		89′	6″	
Sand	20′	6″	110′		
Gravel	2′	3″	112′	3″	
Sand	19′	8″	131′	11″	
Light slate	10′	5″	142′	4″	
Blue slate	2′	10″	145′	2″	
Coal, Lower Verne?	1′		146′	2″	at 454 A. T.
Fire clay	4′		150′	2″	
Light slate	2′		152′	2″	
Blue slate	7′		159′	2″	
Coal, Middle Rider		10″	160′		at 440 A. T.
Fire clay	3′	2″	163′	2″	
Gray rock	12′	8″	175′	10″	
Light slate	7′	4″	183′	2″	
Coal, Saginaw coal		8″	183′	10″	at 416 A. T.
Fire clay	5′		188′	10″	
Blue slate	6′	8″	195′	6″	
Sandrock	5′		200′	6″	

TEST HOLE NO. 187.

In the S. W. ¼ of the N. E. ¼ of Section 15, T. 13 N., R. 4 E., the elevation above tide is 600.′

Clay	74′		74′		
Hardpan	10′		84′		
Sand	3′		87′		
Clay	49′	5″	136′	5″	
Sand	2′		138′	5″	
Slate	3′	1″	141′	6″	
Coal, Upper Verne		9″	142′	3″	at 458 A. T.
Fire clay	1′	5″	143′	8″	
Blue slate	30′		173′	8″	
Gray rock	19′		192′	8″	
Slate and coal, Lower Verne	2′	6″	195′	2″	at 405 A. T.
Gray rock	3′	2″	198′	4″	
Sandrock		8″	199′	0″	

TEST HOLE NO. 188.

In the E. ½ of the S. E. ¼ of Section 33, T. 14 N., R. 4 E., elevation above tide is 600.′

Clay	85′		85′		
Sand	5′		90′		
Gravel	4′		94′		
Slate	2′		96′		
Sandrock	6′		102′		
Blue slate	1′		103′		
Coal, Upper Rider		7″	103′	7″	at 496 A. T.
Fire clay	4′		107′	7″	
Light slate	16′		123′	7″	

Coal, Upper Verne		1.5"	123'	8.5" at 476 A. T.
Light slate	15'		138'	
Coal, Rider of Lower Verne		4"	139'	at 461 A. T.
Light slate	2'		141'	
Blue slate	9'		150'	
Coal, Lower Verne		6.5"	150'	6.5" at 450 A. T.
Fire clay	3'		153'	6.5"
Blue slate	6'	2"	159'	8.5"
Sandrock	1'	5"	161'	2"

TEST HOLE NO. 189.

In the S. ½ of the N. ½ and the S. E. ¼ of the S. W. ¼ of Section 16, T. 14 N., R. 4 E., elevation above tide is 595-605.'

Clay	55'		55'	
Hardpan	37'		92'	
Light slate	3'		95'	
Salzburg coal	6'		101'	at 499 A. T.
Sandrock	1'	6"	102'	6"
Coal		3"	102'	9" at 497 A. T.
Fire clay	5'	3"	108'	
Blue slate	7'	6"	115'	6"
Sandrock	1'		116'	6"
Blue slate	2.	6"	119'	
Fire clay	2'		121'	
Sandrock	1'		122'	
Fire clay	1'	6"	123'	6"
Black slate	2'	8"	126'	2"
Fire clay	2'	4"	128'	6"
Blue slate	29'	6"	158'	
Coal	4'		162'	at 438 A. T.
Slate	....		....	

TEST HOLE NO. 190.

Same location as No. 189. Elevation above tide is 595-605.'

Clay	53'		53'	
Hardpan	50'		103'	
Sand	3'		106'	
Hardpan	13'		119'	
Blue slate	5'	9"	124'	9"
Coal, Upper Rider	2'	3"	127'	at 473 A. T.
Blue slate	1'	3"	128'	3"
Coal		6"	128'	9" at 471 A. T.
Sandrock	18'	9"	147'	6"
Coal, Upper Verne		2"	147'	8" at 453 A. T.
Light slate	4'	4"	152'	
Sandrock	7'	3"	159'	3"

TEST HOLE NO. 191.

Same location as 189. Elevation above tide 595-605.'

Clay	51'		51'	
Hardpan	10'		61'	
Gravel	35'		96'	
Sand	21'		117'	
Light slate	2'		119'	
Blue slate	10'		129'	
Coal, Upper Verne	2'	6"	131'	6" at 469 A. T.
Fire clay	5'		136'	6"
Sand	16'	6"	153'	
Fire clay	2'		155'	
Sand	15'	9"	170'	9"

TEST HOLE NO. 192.

Same location as 189. Elevation above tide 595-605.′

Clay	63′		63′		
Sand	6′		69′		
Hardpan	14′		83′		
Sand	1′		84′		
Gravel	4′		88′		
Sandrock	7′	2″	95′	2″	
Gray rock	6′		101′	2″	
Fire clay	3′		104′	2″	
Blue slate	14′		118′	2″	
Fire clay	1′		119′	2″	
Blue slate	1′	4″	120′	6″	
Coal, Upper Verne	2′		122′	6″	at 478 A. T.
Fire clay	2′		124′	6″	
Blue slate	23′		167′	6″	
Coal, Lower Verne	3′	7″	171′	1″	at 429 A. T.
Fire clay	3′		174′	1″	
Sandrock	17′	3″	191′	4″	

TEST HOLE NO. 193.

In the S. ½ of the N. ½ and the S. E. ¼ of the S. W. ¼ of Section 16, T. 14 N., R. 4 E., elevation above tide is 595-605.′

Clay	50′		50′		
Hardpan	26′		76′		
Gravel	4′		80′		
Clay	20′		100′		
Gravel	4′		104′		
Fire clay	8′		112′		
Slate	7′		119′		
Fire clay	2′		121′		
Slate	2′		123′		
Fire clay	3′		126′		
Slate	3′		129′		
Fire clay	2′		131′		
Light slate	10′		141′		
Blue slate	18′	9″	159′	9″	
Coal, Lower Verne	4′	2″	163′	11′	at 437 A. T.
Slate	1′		164′	11″	

TEST HOLE NO. 194.

In the S. ½ of the N. ½ and the S. E. ¼ of the S. W. ¼ of Section 16, T. 14 N., R. 4 E., elevation above tide is 595-605.′

Clay	52′		52′		
Hardpan	12′		64′		
Clay	10′		74′		
Hardpan	8′		82′		
Clay	10′		92′		
Gravel	2′		94′		
Hardpan	13′		107′		
Gravel	8′		115′		
Fire clay	1′		116′		
Slate	1′		117′		
Gravel	1′		118′		
Fire clay	2′		120′		
Slate	7′		127′		
Blue slate	16′		143′		
Coal, Upper Verne	3′	5″	146′	5″	at 454 A. T.
Fire clay	1′	6″	147′	11″	

TEST HOLE NO. 195.

In the S. ½ of the N. ½ and the S. E. ¼ of the S. W. ¼ of Section 16, T. 14 N., R. 4 E., elevation above tide is 595-605.′

Clay	44′		44′		
Hardpan	18′		62′		
Gravel	7′		69′		
Hardpan	11′		80′		
Sandrock	20′		100′		
Slate	5′		105′		
Fire clay	2′		107′		
Slate	1′		108′		
Fire clay	2′		110′		
Slate	2′		112′		
Slate	4′		116′		
Fire clay	7′		123′		
Slate	18′		141′		
Coal, Upper Verne	3′	11.5″	144′	11.5″	at 455 A. T.
Slate	1′		145′	11.5″	
Fire clay	12′		157′	11.5″	
Slate	4′		161′	11.5″	
Coal, Lower Verne		8″	162′	7.5″	at 437 A. T.
Fire clay	2′		164′	7.5″	
Slate	16′		180′	7.5″	
Blue slate	45′		225′	7.5″	
Sandrock	10 +?		235′	7.5″	

TEST HOLE NO. 196.

In the S. ½ of the N. ½ of the S. E. ¼ of the S. W. ¼ of Section 16, T. 14 N., R. 4 E., the elevation above tide is 595-605.′

Clay	45′		45′		
Sand	25′		70′		
Gravel	15′		85′		
Hardpan	9′	6″	94′	6″	
Sand	7′	6″	102′		
Blue slate	2′		104′		
Sandrock	15′		119′		
Blue slate	1′		120′		
Fire clay	2′		122′		
Blue slate	20′		142′		
Coal, Upper Verne	3′	8″	145′	8″	at 454 A. T.
Fire clay		6″	146′	2″	

TEST HOLE NO. 197.

In the S. W. ¼ of the N. E. ¼ of Section 15, T. 13 N., R. 4 E., elevation above tide is 600.′

Clay	80′		80′		
Sand	6′		86′		
Gravel	2′		88′		
Light slate	18′	4″	106′	4″	
Coal, Upper Rider	4′	5″	110′	9″	at 489 A. T.
Light slate	2′		112′	9″	
Fire clay	4′	2″	116′	11″	
Light slate	32′	1″	149′		
Fire clay	3′		152′		
Light slate	8′		160′		
Coal, Lower Verne Rider	1′	5″	161′	5″	at 439 A. T.
Fire clay		6″	161′	11″	
Gray rock	16′		177′	11″	
Blue slate	4′		181′	11″	
Light slate	4′		185′	11″	
Gray rock	6′	1″	192′		

TEST HOLE NO. 198.

In the S. E. ¼ of the N. W. ¼ of Section 3, T. 13 N., R. 6 E., the elevation above tide is 589.′

Clay	82′		82′		
Hardpan	4′		86′		
Gravel	2′		88′		
Light slate	16′		104′		
Blue slate	1′	5″	105′	5″	
Coal. Upper Rider		6″	105′	11″	at 483 A. T.
Sandrock	4′		109′	11″	
Light slate	3′		112′	11″	
Blue slate	10′		122′	11″	
Coal. Upper Verne	4′		126′	11″	at 462 A. T.
Light slate	3′		129′	11″	
Blue slate	10′		139′	11″	
Coal. Lower Verne		4″	140′	3″	at 449 A. T.
Light slate	1′		141′	3″	
Sandrock	15′		156′	3″	
Light slate	2′		158′	3″	
Coal. Middle Rider		7″	158′	10″	at 430 A. T.
Fire clay	1′		159′	10″	
Sandrock	24′		183′	10″	

TEST HOLE NO. 199.

In the N. E. ¼ of the S. W. ¼ of Section 6. T. 13 N., R. 5 E., the elevation above tide is 584.′

Clay	68′		68′		
Hardpan	12′		80′		
Light slate	9′		89′		
Sandrock	14′	6″	103′	6″	

TEST HOLE NO. 200.

In the S. E. ¼ of Section 21. T. 14 N., R. 4 E., elevation above tide, 599.′

Clay	41′		41′		
Hardpan	11′		52′		
Clay	12′		64′		
Hardpan	10′		74′		
Sand	30′		104′		
Sand and gravel	44′		148′		
Blue slate	6′		154′		
Coal. Lower Verne	1′	S 5′	155′	S 5′	at 443 A. T.
Fire clay	4′		159′	S 5′	
Gray rock	3′	4′	163′		
Fire clay	3′		166′		
Gray rock	18′		184′		
Blue slate	4′		188′		
Gray rock	4′	3′	192′	3′	
Blue slate	8′	5′	200′	8′	
Coal. Saginaw coal		5′	200′	S 5′	at 398 A. T.
Gray rock	4′		204′	S 5′	

TEST HOLE NO. 201

At the E. ¼ post of Section 23. T. 14 N., R. 3 E., elevation above tide is 617.′

Clay	65′	65′	
Sand	21′	86′	
Hardpan	5′	91′	
Sand	11′	102′	
Gravel	12′	114′	

Sand	8′		122′		
Clay	2′		124′		
Sand	16′		140′		
Gravel	2′		142′		
Clay	2′		144′		
Gravel	17′	9″	161′	9″	

TEST HOLE NO. 202.

In the S. W. ¼ of the S. W. ¼ of Section 16, T. 14 N., R. 4 E., elevation above tide is 610.′

Clay	56′		56′		
Hardpan	14′		70′		
Sand and gravel	21′		91′		
Light slate	11′		102′		
Sandrock	4′	6″	106′	6″	
Blue slate	2′	6″	109′		
Fire clay	4′		113′		
Blue slate	7′		120′		
Blue slate	4′		124′		
Sandrock	3′		127′		
Blue slate	1′		128′		
Fire clay	2′		130′		
Blue slate	28′	2″	158′	2″	
Coal, Lower Verne	4′	10″	163′		at 447 A. T.

TEST HOLE NO. 203.

In the W. ½ of the E. ½ of the S. W. ¼ of Section 33, T. 14 N., R. 4 E., the elevation above tide is 605.′

Clay	80′		80′		
Sand	20′		100′		
Hardpan	10′		110′		
Sand	6′		116′		
Light slate	5′		121′		
Fire clay	3′		124′		
Slate	8′		132′		
Fire clay	2′		134′		
Slate	21′		155′		
Coal, Lower Verne		6″	155′	6″	at 450 A. T.
Gray rock	5′		160′	6″	
Light slate	3′		163′	6″	
Fire clay	2′		165′	6″	
Light slate	5′		170′	6″	
Black slate	10′		180′	6″	
Sandrock	6′		186′	6″	
Light slate	3′		189′	6″	
Coal, Saginaw coal	1′	7″	191′	1″	at 414 A. T.

TEST HOLE NO. 204.

In the W. ½ of the E. ½ of the S. W. ¼ of Section 33, T. 14 N., R. 4 E., the elevation above tide is 605.′

Clay	50′		50′		
Sand	15′		65′		
Clay	15′		80′		
Shale—soft	17′		97′		
Sand	15′		112′		
Soapstone (no grit)	10′		122′		
Slate	1′		123′		
Fire clay	2′		125′		
Slate	1′		126′		
Coal, Upper Rider		9″	126′	9″	at 478 A. T.

[illegible]	3′		129′	9″	
[illegible]	16′		145′	9″	
[illegible]		1″	145′	10″	at 459 A. T.
[illegible]	10′		155′	10″	
[illegible]	4′		159′	10″	at 445 A. T.
[illegible]	7′		166′	10″	
[illegible]	6′		172′	10″	
[illegible]	7′	2″	180′		
[illegible]	4′		184′		
[illegible]		9″	184′	9″	at 420 A. T.
[illegible]	18′		202′	9″	
[illegible]	4′		206′	9″	
[illegible]	3′		209′	9″	
[illegible]	19′		228′	9″	

TEST HOLE NO. 205.

[illegible] W. ¼ of section 16, T. 14 N., R. 4 E., elevation

[illegible]	44′		44′	
[illegible]	3′		47′	
[illegible]	8′		55′	
[illegible]	22′		77′	
[illegible]	3′		80′	
[illegible]	2′	8″	82′	8″
[illegible]	6′		88′	8″
[illegible]	3′		91′	8″
[illegible]	3′		94′	8″
[illegible]	4′		98′	8″
[illegible]	1′		99′	8″
[illegible]	1′	6″	102′	2″
[illegible]	2′		104′	2″
[illegible]	1′		105′	2″
[illegible]	10′		115′	2″
[illegible]	2′	1″	117′	3″	at 493 A. T.
[illegible]	1′	6″	118′	9″	
[illegible]	16′		134′	9″	
[illegible]	2′	6″	137′	3″	at 473 A. T.
[illegible]	1′	4″	138′	7″	
[illegible]	5′		143′	7″	
[illegible]	1′	7″	145′	2″	at 465 A. T.
[illegible]	1′		146′	2″	
[illegible]	10′		156′	2″	
[illegible]	12′		168′	2″	
[illegible]	1′	1″	169′	3″	at 441 A. T.
[illegible]	3′		172′	3″	
[illegible]	37′		209′	3″	
[illegible]	1′		210′	3″	
[illegible]	1		211′	3″	

[illegible] NO. 206.

[illegible] Section 16, T. 14 N., R. 4 E., elevation

[illegible]			51′	
[illegible]			92′	
[illegible]			97′	
[illegible]			105′	
[illegible]	4′		109′	3″	at 491 A. T.
[illegible]			149′	3″	
[illegible]			153′	3″	
[illegible]	3		156′	6″	at 444 A. T.
[illegible]	1		157′		

TEST HOLE NO. 207.

In the S. E. ¼ of the N. W. ¼ of Section 16, T. 14 N., R. 4 E., elevation above tide is 610.′

Clay	48′		48′		
Hardpan	20′		68′		
Sand	3′		71′		
Clay	6′		77′		
Sand	23′		100′		
Clay	3′		103′		
Sand	11′		114′		
Clay	7′		121′		
Light slate	11′		132′		
Black slate	18′	7″	150′	7″	
Coal, Upper Verne	4′	6″	155′	1″	at 455 A. T.
Fire clay	3′		158′	1″	

TEST HOLE NO. 208.

In the S. ½ of the N. ½ and the S. E. ¼ of the S. W. ¼ of Section 16, T. 14 N., R. 4 E., elevation above tide is 595-605.′

Clay	63′		63′		
Sand	6′		69′		
Hardpan	14′		83′		
Sand	1′		84′		
Gravel	4′		88′		
Sandrock	7′	2″	93′	2″	
Gray rock	6′		101′	2″	
Fire clay	3′		104′	2″	
Black slate	14′		118′	2″	
Fire clay	1′		119′	2″	
Black slate	1′	4″	120′	6″	
Coal, Upper Rider		2″	120′	8″	at 479 A. T.
Fire clay	2′		122′	8″	
Black slate	23′		145′	8″	
Coal, Upper Verne	3′	7″	149′	3″	at 451 A. T.
Fire clay	3′		152′	3″	
Gray rock	17′	3″	169′	6″	

TEST HOLE NO. 209.

In the S. E. ¼ of the N. W. ¼ of Section 16, T. 14 N., R. 4 E., elevation above tide is 595-605.′

Clay	49′		49′		
Sand	15′		64′		
Clay	6′		70′		
Gravel	12′		82′		
Sandrock	9′		91′		
Black slate	4′		95′		
Sandrock	2′		97′		
Gray rock	12′		109′		
Black slate	5′	4″	114′	4″	
Fire clay	4′		118′	4″	
Gray rock	23′	3″	141′	7″	
Coal, Upper Verne	4′	10″	146′	5″	at 454 A. T.
Fire clay	3′		149′	5″	
Black slate	11′		160′	5″	
Fire clay	5′		165′	5″	
Gray slate	3′		168′	5″	
Black slate	16′		184′	5″	
Sandrock	2′		186′	5″	
Black slate	7′	7″	194′		
Sandrock	1′		195′		

TEST HOLE NO. 210.

In the N. ½ of the N. W. ¼ and the N. W. ¼ of the N. E. ¼ of Section 21 T. 14 N., R. 4 E., elevation above tide is 595-605.′

Clay	50′		50′	
Hardpan	28′		78′	
Sand	6′		84′	
Clay	8′		92′	
Sand	2′		94′	
Gravel	3′	4″	97′	4″
Coal, Salzburg coal	2′		99′	4″ at 501 A. T.
Gray slate	3′	2″	102′	6″
Sandrock	2′	6″	105′	
Light slate	1′	4″	106′	4″
Sandrock	2′	6″	108′	10″
Light slate	20′		128′	10″
Black slate	22′		150′	10″
Coal, Lower Verne	1′	3″	152′	1″ at 448 A. T.
Sandrock		11″	153′	

TEST HOLE NO. 211.

In the N. ½ of the N. W. ¼ and the N. W. ¼ of the N. E. ¼ of Section 21 T. 14 N., R. 4 E., elevation above tide is 595-605.′

Clay	48′		48′	
Hardpan	2′		50′	
Sand	2′		52′	
Clay	10′		62′	
Gravel	20′	5″	82′	5″
Clay	3′	2″	85′	7″
Sandrock	11′		96′	7″
Salzburg Rider		2″	96′	9″ at 504 A. T.
Sandrock	3′	5″	100′	2″
Salzburg coal	3′	4″	103′	6″ at 497 A. T.
Light slate	15′	4″	118′	10″
Black slate	23′		141	′10″
Sandrock	4′		145′	10″
Black slate		3″	146′	1″
Sandrock	1′		147′	1″
Gray rock	3′		150′	1″
Light slate	20′		170′	1″
Sandrock	3′		173′	1″
Coal, Middle Rider?		4″	173′	5″ at 427 A. T.

TEST HOLE NO. 212.

In the N. ½ of the N. W. ¼ and the N. W. ¼ of the N. E. ¼ of Section 21, T. 14 N., R. 4 E., elevation above tide is 595-605.′

Clay	63′		63′	
Sand	6′		69′	
Gravel	15′		84′	
Hardpan	7′		91′	
Clay	16′	6″	107′	6″
Gray rock	4′		111′	6″
Slate	6′		117′	6″
Sandrock	1′	3″	118′	9″
Light slate	29′	10″	148′	7″
Black slate	20′		168′	7″
Gray rock	2′	3″	170′	10″
Black slate	17′	11″	188′	9″
Fire clay	2′		190′	9″

TEST HOLE NO. 213.

In the N. E. ¼ of the S. E. ¼ of Section 1, T. 13 N., R. 4 E., This is 40 rods south of the shaft of the Valley Coal Company, elevation above tide is 584.′

Clay	81′	6″	81′	6″	
Black slate	7′	5″	88′	11″	
Coal	3′	3″	92′	2″	at 492 A. T.

TEST HOLE NO. 214.

In the W. ½ of the S. W. ¼ of the S. E. ¼ of Section 12, T. 13 N., R. 4 E., elevation above tide is 585.′

Sand	18′	18′	
Clay	72′	90′	
Sand	35′	125′	
Clay	10′	135′	
Gravel	2′	137′	
Sand	11′	148′	
Clay	8′	156′	
Sand	4′	160′	
Gravel	2′	162′	

TEST HOLE NO. 215.

In the N. E. ¼ of Section 3, T. 13 N., R. 6 E., elevation above tide is 586.′

Clay	82′		82′		
Hardpan	4′		86′		
Gravel	2′		88′		
Light slate	16′		104′		
Black slate	1′	5″	105′	5″	
Coal, Upper Rider		6″	105′	11″	at 480 A. T.
Sandrock	4′		109′	11″	
Light slate	3′		112′	11″	
Black slate	10′		122′	11″	
Coal, Upper Verne		9″	123′	8″	at 462 A. T.
Light slate	1′		124′	8″	
Sandrock	15′		139′	8″	
Light slate	2′		141′	8″	
Coal, Lower Verne		7″	142′	3″	at 444 A. T.
Fire clay	1′		143′	3″	
Sandrock	24′		167′	3″	

TEST HOLE NO. 216.

Hole No. 1 Salzburg, elevation above tide is 593.′

Clay	79′		79′		
Hardpan	4′	6″	83′	6″	
Slate	1′		84′	6″	
Fire clay	7′		91′	6″	
Slate	1′		92′	6″	
Salzburg coal	1′	9″	94′	3″	at 499 A. T.
Fire clay	2′		96′	3″	
Sandrock	3′		99′	3″	
Slate	6′		105′	3″	
Black slate	4′	5″	109′	8″	
Coal, Upper Verne	4′	9″	114′	5″	at 479 A. T.

TEST HOLE NO. 217.

Hole No. 2 Salzburg, elevation above tide 595.′

Clay	93′		93′	
Black slate	4′		97′	
Salzburg coal		2″	97′	2″ at 498 A. T.
Fire clay	2′	6″	99′	8″
Slate	17′	5″	117′	1″
Coal, Upper Verne	2′	2″	119′	3″ at 476 A. T.
Gray sandrock	6′	6″	125′	9″
Coal, Lower Verne	4′	6″	130′	3″ at 465 A. T.

TEST HOLE NO. 218.

Hole No. 3, Salzburg, elevation above tide is 595.′

Clay	87′		87′	
Fire clay	1′		88′	
Sandrock	1′		89′	
Slate	1′	6″	90′	6″
Fire clay	2′		92′	6″
Sandrock	5′	6″	98′	
Slate	1′		99′	
Sandy fire clay	2′	6″	101′	6″
Salzburg coal	1′	7″	103′	1″ at 492 A. T.
Fire clay	2′		105′	1″
Slate	1′		106′	1″
Black slate	2′		108′	1″
Fire clay	1′		109′	1″
Light slate	1′		110′	1″
Black slate	6′	3″	116′	4″
Coal, Upper Verne	5′	1″	121′	5″ at 474 A. T.

TEST HOLE NO. 219.

Hole No. 4, Salzburg, the elevation above tide is 595.′

Clay	76′		76′	
Hardpan	6′		82′	
Black slate	9′		91′	
Fire clay	3′		94′	
Slate	11′		105′	
Black slate	8′		113′	
Coal, Upper Verne	2′	6.5″	115′	6.5″ at 480 A. T.
Black slate	6′		121′	6.5″
Fire clay	2′		123′	6.5″
Sandy fire clay	4′	6″	128′	
Coal, Lower Verne	3′	8.5″	131′	8.5″ at 463 A. T.
Fire clay	2′		133′	8.5″
Sandy fire clay	2′		135′	8.5″
Black slate	1′	6″	137′	2″
Coal	2′	11″	140′	1″ at 455 A. T.
Fire clay (Splits of Middle Rider?)	3′	6″	143′	7″
Coal	2′	5″	146′	at 449 A. T.
Fire clay	9′		155′	
Slate	2′	6″	157′	6″
Black slate	4′		161′	6″
Fire clay	1′	6″	163′	
Light slate	2′		165′	
Black slate	6′		171′	
Light slate	4′		175′	
Fire clay	5′		180′	
Sandy fire clay	6′		186′	

TEST HOLE NO. 220.

Hole No. 5, Salzburg, elevation above tide is 595.′

Clay	95′		95′	
Black slate	13′	4″	108′	4″
Coal	2′	3″	110′	7″ at 484 A. T.
Fire clay	3′	3″	113′	10″
Black slate		9″	114′	7″
Coal, Upper Verne	3′	9″	118′	4″ at 477 A. T.
Fire clay	1′	6″	119′	10″
Slate	2′		121′	10″
Fire clay	2′	10″	124′	8″
Black slate		9″	125′	5″
Coal and slate, Lower Verne		11″	126′	4″ at 469 A. T.
Sandy fire clay	5′		131′	4″
Sandrock	15′		146′	4″
Slate	6′		152′	4″
Fire clay	3′		155′	4″
Sandrock	4′	6″	159′	10″
Black slate	6′		165′	10″
Sandrock	1′		166′	10″

TEST HOLE NO. 221.

Hole No. 6, Salzburg, elevation above tide is 595.′

Clay	78′		78′	
Hardpan	6′		84′	
Black slate	16′		100′	
Fire clay	3′	6″	103′	6″
Black slate	5′	3″	108′	9″
Coal, Upper Verne	2′	4″	111′	1″ at 484 A. T.
Fire clay	3′		114′	1″
Sandrock	9′		123′	1″
Black slate	2′	6″	125′	7″
Sandy fire clay	8′		133′	7″
Sandrock	2′		135′	7″
Slate	3′	3″	138′	10″
Coal	2′	3″	141′	1″ at 454 A. T.
Black slate	3′	0″	144′	1″

Records from John Werner in Monitor Township, T. 14 N., R. 4 E.

Test Hole Nos. 222-229.

TEST HOLE NO. 222.

In the N. E. ¼ of the N. E. ¼ of Section 20, T. 14 N., R. 4 E., 400-500′ S. of N. line of Sec. On Marrow farm, elevation above tide is 615.′

Clay	75′		75′	
Sand and gravel	32′		107′	
Clay	2′		109′	
Sandrock	8′		117′	
Light slate	26′		143′	
Dark slate	1′		144′	
Coal, Upper Verne		5″	144′	5″ at 471 A. T.
Fire clay		10″	145′	3″
Light slate	7′	9″	153′	
Black slate	9′	8″	162′	8″
Coal, Lower Verne	2′	2″	164′	10″ at 450 A. T.
Fire clay	1′	2″	166′	

TEST HOLE NO. 223.

In the N. W. ¼ of the N. E. ¼ of Section 20, T. 14 N., R. 4 E. On Shaw farm north of railroad, elevation above tide is 615.′

Clay	104′		104′		
Sand	8′		112′		
Hardpan	3′		115′		
Light slate	4′		119′		
Black slate	24′		143′		
Coal, Upper Verne	3′	3″	146′	3″	at 469 A. T.

TEST HOLE NO. 224.

In the N. E. ¼ of the S. E. ¼ of Section 20, T. 14 N., R. 4 E, elevation above tide is 600.′

Clay	62′		62′		
Sand and gravel	4′		66′		
Clay	8′		74′		
Sand and gravel	8′		82′		
Hardpan	12′		94′		
Sandrock	6′		98′		
Salzburg coal		4″	98′	4″	at 502 A. T.
Slate	11′	8″	110′		
Light slate	37′		147′		
Sandrock	3′		150′		
Light slate	20′		170′		

TEST HOLE NO. 225.

In the S. E. ¼ of the N. W. ¼ of Section 20, T. 14 N., R. 4 E., elevation above tide is 602.′

Clay	60′		60′		
Sand and gravel	71′		131′		
Dark slate	6′	6″	137′	6″	
Coal, Upper Verne	3′	6″	141′		at 461 A. T.
Fire clay	4′	6″	145′	6″	
Light slate	8′	6″	154′		
Coal, Lower Verne		3″	154′	3″	at 448 A. T.
Fire clay		3″	154′	6″	
Light slate	26′		180′	6″	
Sandrock	9′		189′	6″	
Slate	12′		201′	6″	
Gray shale	7′		208′	6″	
Light slate	3′		211′	6″	
Sandrock	3′		214′	6″	

TEST HOLE NO. 226.

In the center of the S. W. ¼ of the S. W. ¼ of Section 20, T. 14 N., R. 4 E., elevation above tide is 607.′

Hard clay	38′		38′
Soft clay	13′		51′
Hard clay	6′		57′
Sandy clay	10′		67′
Sand and gravel	17′		84′
Hardpan	3′		87′
Sandy clay	21′		108′
Sand	10′		118′
Clay	15′		133′
Sand	7′		140′
Clay	15′		155′
Sand	3′		158′
Soapstone	25′		183′

TEST HOLE NO. 227.

In the E. ½ of the E. ½ of the S. W. ¼ of Section 20, T. 14 N., R. 4 E., elevation above tide is 603′.

Clay	55′	55′
Sand	3′	58′
Clay	26′	84′
Sand	4′	88′
Clay	21′	109′
Sand	15′	124′
Gray shale	8′	132′
Sandrock	6′	138′
Gray shale	26′	164′
Fire clay	3′	167′
Sandrock	13′	180′

TEST HOLE NO. 228.

In the W. ½ of the E. ½ of the S. W. ¼ of Section 20, T. 14 N., R. 4 E., elevation above tide is 605′.

Clay	55′	55′
Sand	3′	58′
Clay	36′	94′
Sand	49′	143′

TEST HOLE NO. 229.

In the W. ½ of the S. E. ¼ of Section 20, T. 14 N., R. 4 E., elevation above tide is 600′.

Clay	55′		55′	
Sand and gravel	26′		81′	
Clay	7′		88′	
Sand and gravel	2′		90′	
Clay	4′		94′	
Sandrock	2′		96′	
Light slate	1′	8″	97′	8″
Salzburg coal	3′	10″	101′	6″ at 499 A. T.
Dark slate	1′		102′	6″
Fire clay	1′	6″	104′	

Bangor Township, West Bay City, Monitor Township. Goff Paul.

Test Hole Nos. 230-288.

TEST HOLE NO. 230.

On the E. and W. ¼ line of Section 3, ¼ mile E. of the W. line, T. 14 N., R. 5 E., Goff Paul, Driller, elevation above tide is 583′.

Sand	11′		11′	
Clay	71′		82′	
Hardpan	3′		85′	
Quicksand and gravel	5′		90′	
Quicksand and fine gravel with streaks of hardpan	70′		160′	
Slate	9′		169′	
Hard rock	6′	3″	175′	3″
Black slate	11′	7″	186′	10″
Coal, Saginaw coal?	2′	1″	188′	11″ at 394 A. T.
Fire clay	27′		215′	11″
Slate with streaks of hard rock	60′	4″	276′	3″

Black slate	11′		287′	3″	
Hard rock	3′		290′	3″	
Black slate	4′		294′	3″	
Coal, Lower coal	1′	2″	295′	5″	at 288 A. T.
Fire clay	30′		325′	5″	
Hard rock	2′		327′	5″	
Slate	20′		347′	5″	
Black slate	7′		354′	5″	
Bangor coal Rider		7″	355′		at 228 A. T.
Fire clay	18′	7″	373′	7″	
Hard rock	4′	8″	378′	3″	
Slate	22′		400′	3″	
Black slate	13′		413′	3″	
Bangor coal	1′	9″	415′		at 168 A. T.
Fire clay	27′		442′		
Hard rock	23′		465′		

TEST HOLE NO. 231.

In the center of the S. line of Section 10, T. 14 N., R. 5 E., elevation above tide is 583′.

Clay	75′		75′		
Sandrock	4′	6″	79′	6″	
Crevice	1′	8″	81′	2″	
Sandrock	....		....		

TEST HOLE NO. 232.

On the east line of Section 13, just north of quarter post, T. 14 N., R. 4 E., elevation above tide is 600′.

Clay	80′		80′		
Hardpan and stone	6′		86′		
Then blue slate	19′		105′		
Black slate	4′		109′		
Salzburg coal	3′	10″	112′	10″	at 488 A. T.
Fire clay	20′		132′	10″	

TEST HOLE NO. 233.

At the N. quarter post of Section 10, T. 14 N., R. 5 E., elevation above tide is 583′.

Sand, gravel, stones and old rotten logs	18′		18′		
Clay	60′		78′		
Hardpan	3′		81′		
Water course. Will take water very fast. Natural head from surface ..	21′		102′		
Hard rock	3′		105′		
Sandrock with 80% brine	62′		167′		
Hardrock	5′	2″	172′	2″	
Slate	41′	6″	213′	8″	
Black slate	3′		216′	8″	
Coal, Lower Rider		6″	217′	2″	at 366 A. T.
Slate mixed with hard streaks of rock	63′		280′	2″	
Slate	7′		287′	2″	
Fire clay	20′		307′	2″	
Coal, Lower coal	3′	2″	310′	4″	at 273 A. T.
Fire clay	10′		320′	4″	

TEST HOLE NO. 234.

Center of N. and S. ¼ line of Section 10, T. 14 N., R. 5 E., elevation above tide is 583′.

On top muck and clay with old logs and shells at 30′ in the muck?	75′		75′		
Hardpan	4′		79′		
Crevice	1′		80′		
The tools dropped through. This will take all the drainage from the surface. Crevice runs N. E. and S. W?					
Sandrock	50′		130′		
Slate	18′		148′		
Black slate	14′	6″	162′	6″	
Coal, Middle rider		6″	163′		at 420 A. T
Fire clay	3′	2″	166′	2″	
Slate and hard rock	25′		191′	2″	
Dark slate	10′		201′	2″	
Light slate	23′		224′	2″	
Slate and hard rock	40′		264′	2″	
One bed of hard rock	33′		297′	2″	
Blue slate	15′		312′	2″	
Black slate	3′		315′	2″	
Coal, Lower coal	2′	2″	317′	4″	at 266 A. T.
Fire clay	6′		323′	4″	

TEST HOLE NO. 235.

South line of Section 10 and east 80 rod corner, T. 14 N., R. 5 E., elevation above tide is 582′.

Clay	78′		78′		
Sandrock	25′		103′		
Light slate	15′		118′		
Blue slate	10′		128′		
Light slate	2′		130′		
Fire clay	2′		132′		
Coal, Verne coal		3″	132′	3″	at 450 A. T.
Light slate	10′		142′	3″	
Dark slate	10′		152′	3″	
Sandrock	4′		156′	3″	
Blue slate	8′		164′	3″	
Sandstone and slate mixed	10′		174′	3″	
Light colored slate	15′		189′	3″	
Dark colored slate	20′		209′	3″	
Fire clay	6′		215′	3″	
Light blue slate	15′	7″	230′	10″	
Coal, Saginaw coal?	1′	4″	232′	2″	at 350 A. T.
Fire clay	3′		235′	2″	
Hard rock	10′		245′	2″	
Light slate	2′		247′	2″	
Hard rock	3′		250′	2″	
Hard blue slate and sandrock	4′		254′	2″	
Fire clay	2′		256′	2″	
Hard rock (sandy limestone)	6′		262′	2″	
Light slate	11′		273′	2″	
Blue slate	20′		293′	2″	
Sandrock	2′		295′	2″	
Fire clay	1′		296′	2″	
Coal, Lower Rider	2′	6″	298′	8″	at 284 A. T.
Hard rock	5′	1″	303′	9″	
Blue slate		3″	304′		
Fire clay		3″	304′	3″	
Coal, Lower coal		2″	304′	5″	at 278 A. T.
Slate		3″	304′	8″	
Fire clay	7′		311′	8″	

TEST HOLE NO. 236.

Eighty rods S. and 100 rods W. of the N. E. corner of Section 9, T. 14 N., R. 5 E., elevation above tide is 586'.

Clay	80'		80'		
Hardpan and gravel	10'		90'		
Sandy slate	20'	6"	110'	6"	
Dark slate	10'		120'	6"	
Sandrock	14'	6"	135'		
Sandy slate	15'		150'		
Hard sandy limestone	10'		160'		
Light colored slate	2'		162'		
Sandy slate	4'		166'		
Sandy slate and hard flinty rock	12'		178'		
Sandrock	10'		188'		
Dark slate	5'		193'		
Very hard white sandrock	8'		201'		
Sandy slate and hard sandrock	20'		221'		
Bluish black slate	19'	5"	240'	5"	
Hard sandy limestone	9'	6"	249'	11"	
Hard sandy slate	15'	7"	265'	6"	
Hard rock	4'	6"	270'		
Sandy slate and hard rock	15'		285'		
Light slate	4'		289'		
Hard rock	8'		297'		

TEST HOLE NO. 237.

Center of N. and S. $\frac{1}{8}$ line, E. part of Section 10, T. 14 N., R. 5 E., elevation above tide is 583'.

Sand	3'		3'		
Clay	78'		81'		
Hardpan	6'		87'		
Crevice of fine sand and gravel. Will take water	2'	1"	89'	1"	
Sandrock	30'		119'	1"	
Hard rock (sandy limestone?)	7'		126'	1"	
Blue slate	20'		146'	1"	
Sandrock	30'		176'	1"	
Blue slate	10'		186'	1"	
Hard rock	3'		189'	1"	
Black slate	6'		195'	1"	
Coal, Saginaw coal	1'	2"	196'	3"	at 387 A. T.
Fire clay	8'		204'	3"	
Slate	30'		234'	3"	
Hard rock	5'		239'	3"	
Slate	11'		250'	3"	
Coal, Lower Rider		6"	250'	9"	at 332 A. T.
Fire clay	3'		253'	9"	
Black slate	7'		260'	9"	
Coal	1'	4"	262'	1"	at 321 A. T.
Fire clay	4'		266'	1"	
Hard rock	3'		269'	1"	
Black slate	12'		281'	1"	
Coal	1'	2"	282'	3"	at 301 A. T.
Fire clay	7'		289'	3"	
Slate	20'		309'	3"	
Black slate	7'		316'	3"	
Coal, Lower coal		7"	316'	10"	at 267 A. T.
Fire clay	16'		332'	10"	

TEST HOLE NO. 238.

On the N. and S. ¼ line of Section 10, ¼ mile of N. from the S. end, T. 14 N., R. 5 E., elevation above tide is 583'.

Sand	2'		2'		
Clay	75'		77'		
Hardpan	4'		81'		
Crevice? with fine sand and gravel serving for the purpose of underground drainage. Water head 18' from level of ground.					
Sandrock	50'		131'		
Slate	18'		149'		
Black slate	4'	6"	153'	6"	
Coal, Middle Rider		6"	154'		at 429 A. T.
Fire clay	3'	2"	157'	2"	
Slate and hard rock mixed	25'		182'	2"	
Dark blue slate	10'		192'	2"	
Light slate	23'		215'	2"	
Slate and hard rock mixed	40'		255'	8"	
Hard rock	33'		288'	8"	
Blue slate	15'		303'	8"	
Black slate	3'		306'	8"	
Coal, Lower coal	3'	1"	309'	9"	at 273 A. T.
Fire clay	2'		311'	9"	
Black slate	4'		315'	9"	
Bangor coal Rider	2'		317'	9"	at 266 A. T.
Fire clay, hard rock	20'		337'	9"	

TEST HOLE NO. 239.

Quarter section line, ¼ mile N. of the S. end of Section 3, T. 14 N., R. 5 E., elevation above tide is 583'.

Sand	4'		4'		
Clay	76'		80'		
Sandrock	80'		160'		
Hard rock—limy	9'		169'		
Slate with streaks of very hard rock	63'		232'		
Black slate	17'		249'		
Coal, Lower Rider	1'	3"	250'	3"	at 333 A. T.
Fire clay	21'		271'	3"	
Hard rock	6'	4"	277'	7"	
Slate	33'	2"	310'	9"	
Hard rock	8'		318'	9"	
Black slate	14'	9"	333'	6"	
Bangor coal Rider	1'	11"	335'	5"	at 248 A. T.
Fire clay	24'	8"	360'	1"	
Hard rock	3'	2"	363'	3"	
Slate	21'		384'	3"	
Black slate	7'		391'	3"	
Bangor coal		3"	391'	6"	at 192 A. T.
Fire clay	13'		404'	6"	
Hard rock	2'		406'	6"	

TEST HOLE NO. 240.

On the W. line of Section 3, ¼ mile S. of Saginaw Bay, T. 14 N., R. 5 E., elevation above tide is 584'.

Sand	3'		3'		
Clay	76'		79'		
Quicksand	70'		149'		
Hard rock	3'	6"	152'	6"	
Sandrock	21'		173'	6"	

Slate	30′		203′	6″	
Hard rock	2′	7″	206′	1″	
Slate with streaks of hard rock	40′		246′	1″	
Black slate	10′		256′	1″	
Coal, Lower Rider	1′	4″	257′	5″	at 327 A. T.
Fire clay	7′		264′	5″	
Hard sandrock	11′	8″	276′	1″	
Slate	23′		299′	1″	
Hard rock	3′		302′	1″	
Slate	5′		307′	1″	
Black slate	7′		314′	1″	
Coal, Lower coal	1′	9″	315′	10″	at 268 A. T.
Fire clay	13′		328′	10″	
Hard rock	8′	2″	337′		

TEST HOLE NO. 241.

On the N. and S. ¼ line, S. part opposite Chesley Wheeler, in Section 4 T. 14 N., R. 5 E., elevation above tide is 585′.

Sand	3′		3′		
Clay	72′		75′		
Hardpan	4′		79′		
Quicksand and gravel	26′		105′		
Slate	20′		125′		
Sandrock	18′		143′		
Hard rock	2′		145′		
Slate	11′		156′		
Sandrock	27′		183′		
Hard rock	6′		189′		
Slate	18′		207′		
Black slate	7′		214′		
Coal, Saginaw coal		7″	214′	7″	at 371 A. T.
Fire clay	8′	3″	222′	10″	
Slate	20′		242′	10″	
Hard rock	8′		250′	10″	
Slate	30′		280′	10″	
Hard rock	18′		298′	10″	
Black slate	2′		300′	10″	
Coal, Lower coal	2′	1″	302′	11″	at 283 A. T.
Fire clay	21′		323′	11″	

TEST HOLE NO. 242.

At the N. E. corner of Section 19, T. 14 N., R. 5 E., elevation above tide is 602′.

Clay	76′		76′		
Hardpan	4′	3″	80′	3″	
Quicksand and gravel	27′		107′	3″	
Blue slate	39′		146′	3″	
Hard rock	3′	2″	149′	5″	
Dark slate	2′		151′	5″	
Coal, Lower Verne	1′	4″	152′	9″	at 450 A. T.
Fire clay	7′		159′	9″	
Blue slate	29′		188′	9″	
Fire clay	3′	1″	191′	10″	
Dark slate	4′		195′	10″	
Coal, Saginaw coal		11″	196′	9″	at 405 A. T.
Fire clay	7′		203′	9″	
Hard sandy rock	2′	1″	205′	10″	
Blue slate	18′		223′	10″	
Black slate	7′		230′	10″	
Coal, Lower Rider	1′	2″	232′		at 370 A. T.
Fire clay	2′	7″	234′	7″	
Hard sandy rock	11′		245′	7″	

TEST HOLE NO. 243.

In the N. E. ¼ of the N. E. ¼ of Section 19, T. 14 N., R. 5 E., Bay Co., elevation above tide is 602′.

Clay	77′	2″	77′	2″	
Gravel	3′		80′	2″	
Blue slate	27′		107′	2″	
Black slate	33′		140′	2″	
Coal, Lower Verne	2′		142′	2″	at 460 A. T.
Black slate	1′	2″	143′	4″	
Fire clay	3′		146′	4″	
Hard rock	1′	2″	147′	6″	
Blue slate	41′		188′	6″	
Black slate	4′		192′	6″	
Coal, Saginaw coal?	1′	3″	195′	9″	at 409 A. T.
Fire clay	4′	1″	197′	10″	
Hard rock	2′		199′	10″	
Blue slate	49′		248′	10″	
Dark slate	21′		269′	10″	
Hard rock	1′	2″	271′		
Hard sandy rock	22′		293′		

TEST HOLE NO. 244.

In the N. W. ¼ of Section 2, T. 13 N., R. 5 E., elevation above tide is 600′.

Clay	86′		86′		
Quicksand and gravel	21′		107′		
Blue slate	40′		147′		
Light colored slate	33′		180′		
Hard sand rock	7′		187′		
Slate	61′	3″	248′	3″	
Hard sand rock	21′	1″	269′	4″	
Black slate	41′	7″	310′	11″	
Coal, Lower coal	1′	6″	312′	5″	at 288 A. T.
Fire clay	9′		321′	5″	
Slate	21′		342′	5″	

TEST HOLE NO. 245.

In the center of the N. E. ¼ of Section 2, T. 13 N., R. 5 E., elevation above tide is 600′.

Clay	81′		81′		
Hard rock	3′		84′		
Slate	21′		105′		
Black slate	3′	2″	108′	2″	
Salzburg coal		10″	109′		at 491 A. T.
Fire clay	2′	1″	111′	1″	
Hard rock	1′		112′	1″	
Sandrock, good water	8′	3″	120′	4″	

TEST HOLE NO. 246.

In the S. ½ of the S. E. ¼ of Section 7, T. 13 N., R. 5 E., elevation above tide is 583′.

Clay	81′		81′		
Hardpan	14′		95′		
Boulders	2′	1″	97′	1″	
Quicksand and gravel	21′		118′	1″	
Slate	8′		126′	1″	
Sandrock with good water	4′	7″	130′	8″	

TEST HOLE NO. 247.

In the N. E. ¼ of the N. W. ¼ of Section 19, T. 14 N., R. 5 E., elevation above tide is 602′.

Clay	83′		83′	
Blue slate	21′		104′	
Hard rock	2′	1″	106′	1″
Blue slate	11′		117′	1″
Black slate	9′	8″	126′	9″
Coal, Upper Verne	2′	1″	128′	10″ at 474 A. T.
Black slate	1′	2″	130′	
Fire clay	5′	8″	135′	8″
Blue slate with hardstreaks	40′		175′	8–
Hard rock	6′		181′	8″
Blue slate	21′		202′	8″
Black slate	3′	7″	206′	3″
Coal, Saginaw coal	1′	2″	207′	5″ at 395 A. T.
Fire clay	4′		211′	5″
Hard rock	11′		222′	5″

TEST HOLE NO. 248.

In the E. ½ of the N. W. ¼ of the N. E. ¼ of Section 19, T. 14 N., R. 5 E., elevation above tide is 600′.

Clay	81′		81′	
Blue slate	29′		110′	
Hard sandy lime rock	7′		117′	
Dark slate	20′		137′	
Coal, Lower Verne	2′	4″	139′	4″ at 461 A. T.
Fire clay	9′		148′	4″
Slate	23′		171′	4″
Hard rock	3′	2″	174′	6″
Dark slate	37′	8″	212′	2″
Black slate	5′	9″	217′	11″
Coal, Lower Rider	2′	10″	220′	9″ at 379 A. T.
Fire clay	3′	2″	223′	11″
Blue slate	27′		250′	11″
Light colored slate	19′		269′	11″
Hard rock	3′	7″	273′	6″
Dark slate	21′		294′	6″
Black slate	4′	5″	298′	11″
Coal, Lower coal	1′	2″	300′	1″ at 300 A. T.
Black slate	2′	1″	302′	2″
Fire clay	4′	9″	306′	11″
Hard sandrock	26′		332′	11″

TEST HOLE NO. 249.

In the S. E. part of the S. E. ¼ of the N. W. ¼ of Section 32, T. 15 N., R. 5 E., elevation above tide is 584′.

Sand	8′		8′	
Clay	73′		81′	
Sandrock	20′		101′	
Blue slate	8′	8″	109′	8″
White slate	11′	10″	121′	6″
Black slate	8′		129′	6″
Coal, Lower Verne?	1′	2″	130′	8″ at 453 A. T.
Slate	1′		131′	8″
Fire clay	8′		139′	8″
Hard sandrock	20′		159′	8″
Blue slate	18′		177′	8″
Hard sandrock	26′		203′	8″

TEST HOLE NO. 250.

At the dynamite works ¼ mile E. of the M. C. Depot at Kawkawlin Village, elevation above tide is 600,′ more or less.

Clay with boulders	80′		80′		
Slate	27′		107′		
Hard rock	3′		110′		
Slate	18′		128′		
Sandrock	4′		132′		
Slate and hard rock	32′		164′		

TEST HOLE NO. 251.

At the Parks school, the N. E. ¼ of the N. E. ¼ of Section 20, T. 14 N., R. 5 E. On Clara St. from N. Walnut to N. Linn, W. Bay City, elevation above tide is 600′.

Sand	2′		2′		
Clay	81′		83′		
Sand		6″	83′	6″	
White rock or fire clay	7′	8″	91′	2″	
Crevice (seam) with good water head 10′ less top. Big supply	1′	2″	92′	4″	
Blue slate	3′		95′	4″	

TEST HOLE NO. 252.

At the Central school in the N. E. ¼ of the S. W. ¼ of Section 20, T. 14 N., R. 5 E. On John St. between S. Center and S. Freemont, W. Bay City, elevation above tide is 595′.

Clay	81′	7″	81′	7″	
Blue slate	27′	6″	109′	1″	
Black slate	6′		115′	1″	
Coal, Upper Verne		2″	115′	3″	at 480 A. T.
Fire clay	3′		118′	3″	
Blue slate	21′		139′	3″	
Sandy slate	18′		157′	3″	
Sandrock and salt water	4′		161′	3″	

TEST HOLE NO. 253.

At the Corbin school in the S. E. ¼ of the S. E. ¼ of Section 17, T. 14 N., R. 5 E. On Fulton St., from Litchfield to N. Walnut, W. Bay City, elevation above tide is 594′.

Sand and black muck with old logs and shells on top of clay	33′		33′		
Clay	50′		83′		
Black slate	18′		101′		
Crevice (stratum) with plenty of water, smell like sulphur		11″	101′	11″	
Black slate	3′	2″	105′	1″	
Coal, Upper Rider		10″	105′	11″	at 488 A. T.
Fire clay	3′		108′	11″	

TEST HOLE NO. 254.

At the Dennison school in the S. W. ¼ of the N. W. ¼ of Section 20, T. 14 N., R. 5 E. On W. Indiana St. from May to N. Kiesel, W. Bay City, elevation above tide is 602′.

Clay	83′	83′	
Blue slate	21′	104′	
Black slate	16′	120′	
Coal, Upper Verne	3′ 7″	123′ 7″	at 478 A. T.
Fire clay	3′	126′ 7″	
Sandy rock	14′	140′ 7″	

TEST HOLE NO. 255.

At the Kolb school well in the N. E. ¼ of the N. W. ¼ of Section 29, T. 14 N., R. 5 E. On Muth St. from S. Fremont to S. Chilson, West Bay City, elevation above tide is 597′.

Clay	87′	87′	
Black slate rotten or broken, drill fell in it	21′	108′	
Light slate	12′ 9″	120′ 9″	
Dark slate	11′	131′ 9″	
Blue slate with hard rock	21′	152′ 9″	
Sandrock	12′ 6″	165′ 3″	

TEST HOLE NO. 256.

In the N. E. ¼ of the N. E. ¼ of Section 20, T. 14 N., R. 5 E. Corner Florence and Henry Sts., W. Bay City, elevation above tide is 595.′

Clay	83′	83′	
Slate	12′ 2″	95′ 2″	
Very hard rock	2′ 7″	97′ 9″	
Black slate	11′	108′ 9″	
Coal, Upper Verne	3′ 8″	112′ 5″	at 483 A. T.
Fire clay	4′	116′ 5″	

TEST HOLE NO. 257.

Handy Bros. Mill well in the S. W. ¼ of the N. E. ¼ of Section 29, T. 14 N., R. 5 E. Corner of Main and Jackson Streets, W. Bay City, elevation above tide is 596′.

Clay	88′	88′	
Hardpan	3′	91′	
Black slate	39′ 6″	130′ 6″	
Coal, Lower Verne	2″	130′ 2″	at 466 A. T.
Fire clay	3′	133′ 8″	
Sandrock	62′	195′ 8″	

TEST HOLE NO. 258.

Monitor Shaft record. June, 1895. In the S. W. ¼ of the S. E. ¼ of Section 28, T. 14 N., R. 4 E., elevation above tide is 602′.

Hard reddish colored clay full of gravel to	26′	26′	
Blue clay	14′ 8″	40′ 8″	
Very black clay with limbs of trees—ash, oak, and maple. Could see the grain of wood and shape of leaves	4′ 5″	45′ 1″	
Blue clay	15′	60′ 1″	
Hardpan, sandy clay and gravel	21′	81′ 1″	

Seam of quicksand		10″	81′	11″	
Hardpan	8′		89′	11″	
Quicksand and plenty of water. Water rising 10′. Thickness		4″	90′	3″	
Hardpan with quicksand streaks	13′		103	4″	
Gravel and sand with pieces of coal as large as an egg	1′	2″	104′	6″	
Dark blue slate	10′		114′	6″	
Black slate	4′		118′	6″	
Coal, Upper Rider	1′	6″	120′		at 482 A. T.
Very white fire clay becoming hard when dry	4′		124′		
Black slate	10′		134′		
Coal, Upper Verne	3′	6″	137′	6″	at 465 A. T.
Slate		2″	137′	8″	
Fire clay	6′		143′	8″	

TEST HOLE NO. 259.

In the S. W. ¼ of the S. E. ¼ of Section 28, T. 14 N., R. 4 E., 800 feet northwest of the Monitor shaft elevation above tide is 602′.

Clay	60′		60′		
Hardpan	7′		67′		
Sand with plenty of gas. Burnt all night	3′		70′		
Hardpan	8′	9″	78′	9″	
Sand and gas	2′	1″	80′	10″	
Hardpan	7′		87′	10″	
Sand and gravel	4′		91′	10″	
Hardpan	7′		98′	10″	
Sand and gravel	1′	3″	100′	1″	
Hardpan	2′		102′	1″	
Gravel	1′		103′	1″	
Blue slate	15′		118′	1″	
Dark slate	4′		122′	1″	
Fire clay	2′		124′	1″	
Blue slate	6′		130′	1″	
Sandy fire clay	30′		160′	1″	

TEST HOLE NO. 260.

In the N. W. ¼ of the S. W. ¼ of Section 28, T. 14 N., R. 4 E., 2,500 feet northwest of the Monitor shaft, elevation above tide is 603′.

Clay	40′		40′		
Gas sand and gravel. Blew sand and stones 50′ in the air.	1′	7″	41′	7″	
Clay	20′		61′	7″	

TEST HOLE NO. 261.

On the N. line of the N. W. ¼ of the N. E. ¼ of Section 33, T. 14 N., R. 4 E., 800 feet southwest of Monitor shaft elevation above tide is 602′.

Clay	60′		60′		
Hardpan	42′		102′		
Blue slate	20′	5″	122′	5″	
Black slate	12′		134′	5″	
Coal, Upper Verne	4′	2″	138′	7″	at 464 A. T.
Slate		2″	138′	9″	
Fire clay	7′		145′	9″	

TEST HOLE NO. 262.

In the center of the S. W. ¼ of the S. W. ¼ of Section 28, T. 14 N., R. 4 E., 3,000 feet west of the Monitor shaft, elevation above tide is 605′.

Clay	62′		62′		
Hardpan and gravel	40′		102′		
Blue slate	30′		132′		
Black slate	1′		133′		
Coal, Upper Verne		1″	133′	1″	at 472 A. T.
Sandy fire clay	30′		163′	1″	
Blue slate with layers of hard rock	30′		193′	1″	
Black slate	4′		197′	1″	
Coal, Saginaw coal	1′	4″	198′	5″	at 407 A. T.
Fire clay	6′		204′	5″	

TEST HOLE NO. 263.

On the E. and W. 80-rod line of the E. ½ of the N. W. ¼ of Section 33, T. 14 N., R. 4 E., 3,000 feet southwest of Monitor shaft, elevation above tide is 603′.

Clay	62′		62′		
Hardpan	41′		103′		
Blue slate	26′		129′		
Black slate	3′		132′		
Coal, Upper Verne	1′	2″	133′	2″	at 470 A. T.
Fire clay	10′		143′	2″	
Hard rock	3′		146′	2″	
Dark slate	21′		167′	2″	
Light colored slate	7′		174′	2″	
Dark slate with hard layers	21′		195′	2″	

TEST HOLE NO. 264.

In the N. E. ¼ of the N. W. ¼ of Section 33, T. 14 N., R. 4 E. This is 1,500 feet southwest of Monitor shaft, elevation above tide is 603.′

Clay	61′		61′		
Hardpan and boulders	42′		103′		
Blue slate	19′		122′		
Black slate	14′		136′		
Coal, Upper Verne	4′	4″	140′	4″	at 463 A. T.
Fire clay	2′		142′	4″	

TEST HOLE NO. 265.

In the S. W. ¼ of the S. E. ¼ of Section 28, T. 14 N., R. 4 E., Test hole 333 feet west of Monitor shaft, elevation above tide is 602′.

Clay	60′		60′		
Hardpan	43′		103′		
Dark blue slate	10′		113′		
Black slate	4′		117′		
Coal, Upper Rider	1′	6″	118′	6″	at 484 A. T.
Fire clay	4′		122′	6″	
Black slate	10′		132′	6″	
Coal, Upper Verne	4′	2″	136′	8″	at 466 A. T.
Slate		2″	136′	10″	
Fire clay	2′		138′	10″	

TEST HOLE NO. 266.

In the N. ½ of the N. ½ of the N. ½ of the N. W. ¼ of the S. E. ¼ of Section 4, T. 14 N., R. 5 E., elevation above tide is 585'.

Clay	81'	81'	
Hardpan	4'	85'	
Crevice	1' 2"	86' 2"	
Hard sandy slate	7'	93' 2"	
Blue slate	6'	99' 2"	
Dark slate	10' 8"	109' 10"	
Black slate	6'	115' 10"	
Coal, Upper Verne	3' 10"	119' 8"	at 465 A. T.
Fire clay	20'	139' 8"	

TEST HOLE NO. 267.

In the S. ½ of the S. ½ of the S. ½ of the S. W. ¼ of the N. E. ¼ of Section 4, T. 14 N., R. 5 E., elevation above tide is 585'.

Clay	81'	81'	
Hardpan	3'	84'	
Crevice	10"	84' 10"	
Hard sandy slate	7'	91' 10"	
Black slate	6'	97' 10"	
Coal with streaks of slate, Upper Rider	4' 2"	102'	at 483 A. T.
Fire clay	8'	110'	

TEST HOLE NO. 268.

In the S. ½ of the S. ½ of the S. ½ of the S. W. ¼ of the N. E. ¼ of Section 4, T. 14 N., R. 5 E., elevation above tide is 585'.

Clay	80'	80'	
Hardpan	3'	83'	
Crevice	5"	83' 5"	
Hard sandy slate	8'	91' 5"	
Blue slate	10'	101' 5"	
Dark slate	9'	110' 5"	
Coal, Upper Verne	4' 3"	114' 8"	at 470 A. T.
Fire clay	6'	120' 8"	

TEST HOLE NO. 269.

Near the E. line of the S. ½ of the N. W. ¼ of the S. E. ¼ of Section 4, T. 14 N., R. 5 E., elevation above tide is 585'.

Clay	82'	82'
Hardpan	3'	85'
Quicksand and gravel with streaks of hardpan	27'	112'

TEST HOLE NO. 270.

In the S. ½ of the N. W. ¼ of the S. E. ¼ of Section 4, T. 14 N., R. 5 E., elevation above tide is 585'.

Clay	81'	81'
Hardpan	3'	84'
Quicksand, gravel and streaks of hardpan	41'	125'

TEST HOLE NO. 271.

In the S. ½ of the N. W. ¼ of the S. E. ¼ of Section 4, T. 14 N., R. 5 E., elevation above tide is 585.′ West of hole No. 269.

Clay	80′	80′	
Blue slate	10′	90′	
Black slate	7′	97′	
Coal, Upper Rider	5′ 10″	102′ 10″	at 482 A. T.
Fire clay	3′	105′ 10″	

TEST HOLE NO. 272.

In the N. ½ of the N. W. ¼ of the S. E. ¼ of Section 4, T. 14 N., R. 5 E., elevation above tide is 585′.

Clay	80′	80′	
Hardpan	2′	82′	
Crevice	1′	83′	
Hard sandy slate	9′	92′	
Blue slate	7′ 10″	99′ 10″	
Black slate	4′	103′ 10″	
Blue slate	7′	110′ 10″	
Black slate	4′	114′ 10″	
Coal, Upper Verne	3′ 10″	118′ 8″	at 467 A. T.
Fire clay	2′	120′ 8″	

TEST HOLE NO. 273.

In the S. ½ of the N. W. ¼ of the S. E. ¼ of Section 4, T. 14 N., R. 5 E., elevation above tide is 585′.

Clay	86′	86′	
Hardpan	3′	89′	
Quicksand	4′	93′	
Hard rock (boulder)	2′	95′	
Quicksand and gravel	1′ 2″	96′ 2″	
Light sand slate	11′	107′ 2″	
Blue slate	20′	127′ 2″	

TEST HOLE NO. 274.

In the N. W. corner of farm, N. E. ¼ of the S. E. ¼ of Section 4, T. 14 N., R. 5 E., elevation above tide is 584′.

Clay	100′	100′	
Hardpan	3′	103′	
Quicksand and gravel	4′	107′	
Slate	10′	117′	
Coal, Upper Verne	3′ 1″	120′ 1″	at 464 A. T.
Fire clay	20′	140′ 1″	

TEST HOLE NO. 275.

On the E. line of the N. E. ¼ of the S. W. ¼ of Section 4, T. 14 N., R. 5 E., elevation above tide is 585′.

Clay	80′	80′
Hardpan	4′	84′
Quicksand and gravel with streaks of hardpan	91′	175′

TEST HOLE NO. 276.

Near the N. E. corner of the S. E. ¼ of the S. W. ¼ of Section 4, T. 14 N., R. 5 E., elevation above tide is 585′.

Clay	81′	81′
Hardpan	3′	84′
Quicksand and gravel with streaks of hardpan	94′	178′

TEST HOLE NO. 277.

About 400′ N. of the E. and W. ¼ line of Section 4, and just E. of the N. and S. ¼ line, T. 14 N., R. 5 E. This hole is near the shaft of Wolverine mine, number 1 now abandoned. Elevation above tide is 585′.

Clay	72′		72′	
Blue slate	1′	6″	73′	6″
White sandstone	12′	5″	85′	11″
Fine white sandstone	7′	1″	93′	
Light slate	5′		98′	
Hard rock		4″	98′	4″
Blue slate	10′	8″	109′	
Black slate	3′		112′	
Coal, Upper Verne	3′	5″	115′	6″ at 470 A. T.
Dark blue slate—parting		6″	115′	11″
Coal		2″	116′	1″ at 469 A. T.
Dark slate		6″	116′	7″
Coal		2″	116′	9″ at 468 A. T.
Fire clay		2″	116′	11″
Black slate		10″	117′	9″
Coal, Slimy coal, Sulphur parting, Coal — Lower Verne	1′	10″	119′	7″ at 466 A. T.
		8″	120′	3″
		18″	121′	9″
	1′		122′	9″
Fire clay	1′		123′	9″

TEST HOLE NO. 278.

Forty rods N. of the center of Section 27, T. 14 N., R. 5 E., elevation above tide is 600′.

Clay	95′		95′	
Rock	4′	6″	99′	6″
Slate	24′	2″	123′	8″
Dark slate	2′	9″	126′	5″
Fire clay	3′		129′	5″
Light shale	4′		133′	5″
Hard rock	3′		136′	5″
Black slate	3′		139′	5″
Hard rock and shale	8′		147′	5″
Hard rock	2′		149′	5″
Red slate	6′		155′	5″
Slate and sandrock	24′		179′	5″
Sandrock	3′		182′	5″
Slate	60′	2″	242′	7″
Hard rock	4′	6″	247′	7″
Sandrock	22′		269′	1″
Hard rock and slate	10′		279′	1″
Sandrock	38′	3″	317′	4″
Sandrock	11′	5″	328′	9″

TEST HOLE NO. 279.

In the N. W. ¼ of the S. E. ¼ of Section 27, T. 14 N., R. 5 E., elevation above tide is 600′.

Clay	88′		88′		
Sand and gravel	5′		93′		
Hard slate	10′		103′		
Blue slate	7′		110′		
Fire clay	7′	6″	117′	6″	
Dark slate	1′	10″	119′	4″	
Fire clay	3′		122′	4″	
Light sandy slate	5′		127′	4″	
Light sandy slate and hard iron carbonate	15′		142′	4″	
Hard rock	3′		145′	4″	
Hard rock	2′	3″	147′	7″	
Sandrock	6′		153′	7″	
Blue slate	2′		155′	7″	
Sandrock and hard slate	15′		170′	7″	
Blue slate	5′		175′	7″	
Sandrock and slate	16′		191′	7″	
Dark slate	1′	7″	193′	2″	
Sandrock and slate	18′	6″	211′	8″	

TEST HOLE NO. 280.

On the E. line and N. 80 rod corner of Section 33, T. 14 N., R. 5 E., elevation above tide is 597′.

Clay	98′		98′		
Black loose shale	2′		100′		
Solid black shale	1′	6″	101′	6″	
Dark blue slate	20′	9″	122′	3″	
Black slate	1′	2″	123′	5″	
Coal, Upper Rider		6″	123′	11″	at 473 A. T.
Fire clay	7′		130′	11″	
Blue slate	4′		134′	11″	
Black slate		8″	135′	7″	
Coal, Upper Verne		3″	135′	10″	at 461 A. T.
Fire clay	11′		146′	10″	
Hardrock	4′		150′	10″	
Blue shale	13′		163′	10″	
Blue shale	20′		183′	10″	
Blue shale	11′	6″	195′	4″	
Sandrock	7′		202′	4″	
Sandrock	28′		230′	4″	
Sandrock	20′		250′	4″	
Sandy slate	10′		260′	4″	
Sandy shale	20′		280′	4″	
Hardrock	6′	2″	286′	6″	
Sandy shale	11′		297′	6″	
Blue slate	1′	7″	299′	1″	
Blue slate	15′		314′	1″	
Blue slate	11′		325′	1″	
Hard sandrock	2′		327′	1″	
Blue slate	15′		342′	1″	
Black slate	4′		346′	1″	
Fire clay	3′		349′	1″	
Fine sandrock	9′	7″	358′	8″	

TEST HOLE NO. 281.

In the S. E. ¼ of the S. E. ¼ of Section 33, T. 14 N., R. 5 E. On Lincoln Ave., 20 rods north of South Center, elevation above tide is 595′.

Clay	2′		2′		
Sand	1′	6″	3′	6″	
Clay	95′		98′	6″	
Black shale	4′		102′	6″	
Black shale	2′		104′	6″	
Black shale (hard)		8″	105′	2″	
Salzburg coal	2′	2″	107′	4″	at 488 A. T.
Fire clay	2′		109′	4″	
Blue slate	4′		113′	4″	
Coal, Upper Rider		6″	113′	10″	at 481 A. T.
Dark blue shale	12′		125′	10″	
Black slate	2′	2″	128′		
Coal, Upper Verne	1′		129′		at 466 A. T.
Fire clay	7′		136′		
Blue slate	21′		157′		
Hard rock	3′		160′		
Slate, hard rock	15′		175′		
Sandrock	25′		200′		
Hard rock	13′	11″	213′	11″	

TEST HOLE NO. 282.

Twenty rods N. of the S. ¼ post of Section 33, T. 14 N., R. 5 E., elevation above tide is 596′.

Clay	90′	7″	90′	7″	
Hardpan and gravel	15′	3″	105′	10″	
Hardrock	1′	10″	107′	8″	
Sand and gravel	2′	4″	110′		
Hardpan	3′		113′		
Quicksand	2′	6″	115′	6″	
Hardpan and gravel	4′	3″	119′	9″	
Quicksand	2′	2″	121′	11″	
Hardpan and gravel	3′	7″	125′	6″	
Quicksand	4′	8″	130′	2″	

TEST HOLE NO. 283.

On the E. ¼ line of Section 16, and 80 rods E. of the W. ¼ post, T. 14 N., R. 5 E., elevation above tide is 590′.

Clay	65′		65′		
Sand	6′		71′		
Clay	8′		79′		
Gravel	1′	3″	80′	3″	
Sandy slate	10′		90′	3″	
Sandrock	12′		102′	3″	
Blue slate	4′		106′	3″	
Sandrock	9′	8″	115′	11″	
Blue slate	4′		119′	11″	
Sandy slate	6′	4″	126′	3″	
Blue shale	5′	7″	131′	10″	
Sandrock	48′		179′	10″	
Dark brown slate	2′		181′	10″	
Coal, Saginaw coal?	3′		184′	10″	at 405 A. T.
Blue slate	4′	2″	189′		
Hard rock	1′	8″	190′	8″	
Sandrock	5′		195′	8″	
Light slate	4′		199′	8″	
Sandrock	15′		214′	8″	
Sandy slate	10′	8″	225′	4″	
Blue slate	11′	5″	236′	9″	

Black slate	5′	3″	242′		
Coal, Lower Rider		3″	242′	3″	at 342 A. T.
Fire clay	4′		246′	3″	
Hard rock	3′	7″	249′	10″	
Dark blue slate	12′		261′	10″	
Sandy slate	7′		268′	10″	
Blue slate	3′		271′	10″	
Light shale	5′		276′	10″	
Hard rock	1′	2″	278′		
Blue slate	12′		290′		
Hard rock	8′		298′		
Blue slate	4′		302′		
Black slate	1′	8″	303′	8″	
Coal, Lower coal	1′	3″	304′	11″	at 285 A. T.
Fire clay	2′	9″	307′	8″	
Hard rock	1′	2″	308′	10″	
Sandrock	2′		310′	10″	
Hard rock	1′	7″	312′	5″	
Hard sandrock	20′		332′	5″	

TEST HOLE NO. 284.

In the S. E. ¼ of Section 23, 120 rods N. of the S. 80-rod corner, T. 14 N., R. 5 E., elevation above tide is 600′.

Sand	11′		11′		
Clay	80′		91′		
Sandrock	20′	7″	111′	7″	
Hard rock	8′		119′	7″	
Sandy slate	2′	3″	121′	10″	
Hard blue slate	4′	2″	126′		
Black slate	1′		127′		
Coal, Upper Verne	2′	9″	129′	9″	at 470 A. T.
Blue slate	1′	4″	131′	1″	
Hard rock		11″	132′		
Fire clay	9′	8″	141′	8″	
Hard rock	3′		144′	8″	
Sandy slate	11′	5″	156′	1″	
Light blue slate	18′	3″	174′	4″	
Fire clay	2′	6″	176′	10″	
Sandrock	16′	3″	193′	1″	
Light slate	2′	1″	195′	2″	
Hard sandrock	4′		199′	2″	
Hard sandrock	3′		202′	2″	

TEST HOLE NO. 285.

In the S. E. ¼ of the N. E. ¼ of Section 23, and the E. 80-rod line, T. 14 N., R. 5 E., elevation above tide is 600′.

Sand	8′		8′		
Clay	80′		88′		
Rotten black slate	5′	8″	93′	8″	
Sandrock	11′		104′	8″	
Light blue slate	6′		110′	8″	
Hard rock	2′	6″	113′	2″	
Sandrock	8′		121′	2″	
Sandy slate	3′		124′	2″	
Light slate	8′		132′	2″	
Blue slate	3′		135′	2″	
Black slate	2′	2″	137′	4″	
Coal, Upper Verne	1′	9″	139′	1″	at 461 A. T.
Blue slate	3′		142′	1″	
Sandy slate	6′		148′	1″	
Fire clay	8′		156′	1″	
Sandy slate	9′	8″	165′	9″	
Sandrock	12′		177′	9″	

TEST HOLE NO. 286.

In the N. W. ¼ of the S. E. ¼ of Section 22, T. 14 N., R. 5 E., elevation above tide is 594.′

Sand		6′		6′	
Clay		90′	6″	96′	6″
Hard rock			10″	97′	4″
Crevice			9″	98′	1″
Hard rock			2″	98′	3″
Crevice			6″	98′	9″
Hard rock		3′	7″	102′	4″
Crevice			5″	102′	9″
Hard rock		2′		104′	9″
Sandrock		11′	3″	116′	
Slate		1′	7″	117′	7″
Sandrock		2′		119′	7″
Light slate		6′	2″	125′	9″
Blue slate		2′		127′	9″
Black slate			6″	128′	3″
White slate		2′		130′	3″
Dark blue slate		5′		135′	3″
Coal	Horizon of Lower Verne	1′	1″	136′	4″ at 458 A. T.
Sandy slate			8″	137′	
Coal			6″	137′	6″ at 457 A. T.
Blue slate		2′	2″	139′	8″
Coal			2″	139′	10″ at 454 A. T.
Blue slate		1′	8″	141′	6″
Coal			3″	141′	9″ at 452 A. T.
Fire clay		6′		147′	9″
Hard rock			8″	148′	5″
Sandrock		13′		161′	5″
Hard rock			4″	161′	9″
Sandrock		10′	3″	172′	

TEST HOLE NO. 287.

Eighty rods N. and W. from the S. E. corner of Section 23, T. 14 N., R. 5 E. Eighty rods north of Center St. on Mich. Central Belt Line, Bay City, elevation above tide is 596.′

Sand	8′		8′	
Clay	78′		86′	
Hardpan	1′	2″	87′	2″
Sand and gravel	5′	3″	92′	5″
Sandrock	20′		112′	5″
Slate and hard rock	14′	8″	127′	1″
Red slate	4′		131′	1″
Hard rock	2′	3″	133′	4″
Light blue slate	3′		136′	4″
Light slate	11′	3″	147′	7″
Sandrock	6′		153′	7″
Hard rock	2′		155′	7″
Dark blue slate	1′	3″	156′	10″
Fire clay	9′		165′	10″

TEST HOLE NO. 288.

One hundred twenty rods north of the S. ¼ post of Section 23, T. 14 N., R. 5 E., elevation above tide is 594.′

Clay	90′	6″	90′	6″
Hard rock	10′		100′	6″
Crevice	9′		109′	6″
Hard rock		2″	109′	8″
Crevice		2″	109′	10″

Hard rock	5′ 7″	115′ 5″		
Sandrock	11′	126′ 5″		
Slate	2′ 7″	129′		
Sandrock	3′	132′		
Light slate	6′ 2″	138′ 2″		
Black slate	1′ 6″	139′ 8″		
Dark slate	5′	145′ 8″		
Coal	1′ 10″	147′ 6″	at 447 A. T.	
Light slate	8′	148′ 2″		
Coal — Horizon of Lower Verne	6′	154′ 2″	at 440 A. T.	
Light shale	2′ 2″	156′ 4″		
Coal	10″	157′ 2″	at 437 A. T.	
Light shale	1′ 8″	158′ 10″		
Coal	6″	159′ 2″	at 435 A. T.	
Fire clay	6′	165′ 2″		
Sandrock	13′	178′ 2″		
Hard rock	10′	188′ 2″		

Records from Captain O. W. Blodgett, Bay City, Michigan

Test Holes Nos. 289-310.

Samples of holes were preserved, and the records are from examination of them by officers of the survey.

TEST HOLE NO. 289.

Mich. Clay Co. In the S. E. ¼ of Section 7, T. 13 N., R. 5 E., elevation above tide is 582.′

Drift	123′	123′
Bluish gray shale	20′	143′
Drab shales less argillaceous	7′	150′
Buff micaceous sandstone	75′	225′
Dove colored shales	5′	230′
Buff micaceous sandstone	20′	250′
Black hard shale	20′	270′
Hard black shale somewhat bituminous	5′	275′
Light buff shale ("fire clay")	8′	283′
Drab shales—sandy	13′	296′
Light gray sandstone somewhat bituminous	4′	300′

TEST HOLE NO. 290.

Middle of the N. E. ¼ of the N. W. ¼ of Section 13, T. 13 N., R. 5 E., elevation above tide is 595.′

Drift	122′	122′
Dove colored shales sandy	30′	152′
Fawn colored sandstone—slightly micaceous	7′	159′
Black slate, coal, bituminous shale	14′ 4″	173′ 4″

TEST HOLE NO. 291.

Just east of the N. and S. quarter line of the S. E. ¼ of the S. W. ¼ of Section 17, T. 13 N., R. 6 E, elevation above tide is 595.′

Drift	108′	108′
Slightly micaceous fawn colored sandstone with argillaceous matter; calcareous	34′	142′

Blue argillaceous shale	3′		145′		
Coal, Lower Verne		10″	145′	10″	at 449 A. T.
Dove colored, slightly micaceous, argillaceous, sandstone, calcareous, bituminous	10′		155′	10″	
Blue shale	2′		157′	10″	
Darker blue shale	7′	7″	165′	5″	
Coal, Middle Rider		8″	166′	1″	at 429 A. T.
Coal and black bituminous shale	8′		174′	1″	
Coal		11″	175′		at 420 A. T.
Light shale—"fire clay"	10′		185′		
Clayey, micaceous slightly calcareous fawn colored sandstone with small amount of bituminous matter	5′	1″	190′	1″	

TEST HOLE NO. 292.

Thirty rods S. of the E. and W. ¼ line of the N. W. ¼ of the S. E. ¼ of Section 17, Merritt township, T. 13 N., R. 6 E., elevation above tide is 594.′

Drift	95′		95′		
Light blue shale	15′		110′		
Micaceous, dove colored sandstone with shaly partings	10′		120′		
Sandy slightly micaceous light blue shale	23′		143′		
Darker shale with some coal, Lower Verne	3′		146′		at 448 A. T.
Dove colored shales	26′		172′		
Dove shale and micaceous fawn colored sandstone	6′		178′		

TEST HOLE NO. 293.

Five rods S. of the N. W. corner of Section 21, T. 13 N., R. 6 E. Munger P. O., elevation above tide is 594.′

Drift	89′		89′		
Dove and gray colored shale	46′		135′		
Drab, micaceous shaly sandstone	2′		137′		
Gray shale	2′	6″	139′	6″	
Dark shale	1′	6″	141′		
Black shale	1′	1″	142′	1″	
Coal, Lower Verne	1′	9″	143′	10″	at 450 A. T.
Light shale "fire clay"	2′	8″	146′	6″	
Dove shales		6″	147′		
Light gray shales	6′	2″	153′	8″	
Light gray shales some bituminous matter	2′	10″	156′	6″	
Gray soft shales	2′	2″	158′	8″	
Coal, Middle Rider	1′	5″	160′	1″	at 434 A. T.
Light shale—"fire clay"		11″	161′		
Light gray micaceous sandstone, becoming more bituminous at the bottom	58′		219′		
Coffee colored shale	16′		235′		
Dark brown shale	15′		250′		
Dove colored micaceous sandstone	10′		260′		
Black argillaceous shale	5′		265′		
Gray micaceous sandstone	32′		297′		

TEST HOLE NO. 294.

F. R. Tennant just E. of house in the S. E. corner of the S. W. ¼ of Section 16, T. 13 N., R. 6 E., elevation above tide is 591.′

Drift	100′		100′		
Gravel	1′		101′		
Dove colored shales	36′	6″	137′	6″	
Fawn colored, micaceous sandstone	25′	5″	162′	11′	

TEST HOLE NO. 295.

In the middle of the S. end of the W. ½ of the S. E. ¼ of Section 16, T. 13 N., R. 6 E., G. W. Tennant, elevation above tide is 591.′

Drift	95′		95′		
Gray sandy shale	38′		133′		
Micaceous dove colored shale	7′		140′		
Micaceous dove colored sandstone	2′	6″	142′	6″	
Buff micaceous sandstone	23′	3″	165′	9″	

TEST HOLE NO. 296.

Patrick Keating about middle of the N. end of the E. ½ of the N. E. ¼ of Section 22, T. 13 N., R. 6 E., elevation above tide is 588.′

Drift	84′		84′		
Gravelly clay-till or ground moraine	1′	1″	85′	1″	
Sandy clay-till or ground moraine	2′		87′		
Dove colored gravelly clay with bits of coal	1′		88′		
Gray gravelly clay		10″	88′	10″	
Bituminous shale and coal		2″	89′		
Drift coal	22′	6″	111′	6″	

TEST HOLE NO. 297.

In the N. W. corner of the E. 100 acres extending the entire east side of the N. E. ¼ of Section 22, T. 13 N., R. 6 E., elevation above tide is 589.′

Drift	87′		87′		
Sand and gravel	5′		92′		
Gray calcareous shale	29′		121′		
Light buff colored shale	2′		123′		
Gray hard shale	15′	6″	138′	6″	
Coal, Lower Verne		3″	138′	9″	at 450 A. T.
Light shale "fire clay" not calcareous, fairly infusible	8′	3″	147′		
Dove colored shale hard	11′	8″	158′	8″	
Gray colored shale, hard calcareous		4″	159′		
Dove colored shale, bits of coal	8′	6″	167′	6″	
White sandstone	14′		181′	6″	

TEST HOLE NO. 298.

Three-fourths way across going W. at S. end of the E. ½ of the S. E. ¼ of Section 15, T. 13 N., R. 6 E., elevation above tide is 588.′

Drift	80′		80′		
Sand and gravel	3′		83′		
Dove colored shale	....		....		
Gray colored shale gradually becoming darker	39′		122′		
Light buff shale "fire clay"	1′		123′		
Blue shale	6′		129′		
Gray shale with blue seam of coal	5′		134′		
Light shale "fire clay"	6′		140′		

TEST HOLE NO. 299.

In the S. E. corner of Section 15, T. 13 N., R. 6 E., elevation above tide is 588.′

Drift	80′		80′	
Gray clay till	1′		81′	
Sand and gravel	2′		83′	
Ochre colored sand, magnetic	2′		85′	
Brown iron bearing sand and effervescing with H Cl Precipitates copper from copper sulphate. Scales bright metallic color—metallic iron[2]	2′		87′	
Dove colored shale	49′		136′	
Hard pearl gray shale	4′		140′	
Hard flaggey light gray shale	20′		160′	

TEST HOLE NO. 300.

Center of N. line of the N. W. ¼ of the N. E. ¼ of Section 21, T. 13 N., R. 6 E., elevation above tide is 591.′

Drift	94′		94′	
Dove colored shale slightly calcareous	44′		138′	
Hard dove colored shale	8′		146′	
Light gray micaceous sandstone	17′		163′	

TEST HOLE NO. 301.

In the N. E. ¼ of the N. W. ¼, middle of the N. side and 10 rods S. of Munger road in Section 22, T. 13 N., R. 6 E., elevation above tide is 589.′

Drift	80′		80′		
Gravel containing chert from the Corniferous, drift coal, etc.	7′		87′		
Light buff colored sandstone	71′		158′		
Coal, Middle Rider		9″	158′	9″	at 430 A. T.
Sandy dove colored shale	10′	3″	169′		

TEST HOLE NO. 302.

In the center of the W. line of the S. E. ¼ of the S. W. ¼, of Section 16, T. 13, N., R. 6 E., elevation above tide is 592.′

Drift	82′		82′		
Buff micaceous sandstone	7′		89′		
Light gray shale	1′		90′		
Black shale and coal	5′	6″	95′	6″	
Salzburg coal		6″	96′		at 496 A. T.
Gray shale	7′		103′		
Light shale—"fire clay"	1′		104′		
Dark shale with bits of coal	1′		105′		
Dove colored shale	1′		106′		
Drab micaceous sandstone	12′		118′		
Lighter micaceous sandstone	32′		150′		
Drab micaceous sandstone	1′		151′		
Fawn colored micaceous sandstone	19′		170′		
Light slightly calcareous shale	4′		174′		
Buff micaceous sandstone	1′		175′		

[2] From drill or broken casing?

TEST HOLE NO. 303.

In the N. E. corner of the S. W. ¼ of the N. W. ¼ of Section 21, T. 13 N., R. 6 E., elevation above tide is 594.'

Drift	90'		90'		
Light gray sandstone	5'		95'		
Light (buff) shale "fire clay"	51'	6"	146'	6"	
Light (pearl) gray micaceous sandstone	3'	6"	150'		
Light buff shale "fire clay"	13'		163'		
Coal and shale	2'		165'		
Coal, Middle Rider	1'	6"	166'	6"	at 428 A. T.
Dove colored shale	8'		174'		
Micaceous buff colored sandstone	2'		176'		

TEST HOLE NO. 304.

In the center of the S. line of the N. E. ¼ of the N. E. ¼ of Section 20, T. 13 N., R. 6 E., elevation above tide is 595.'

Drift	87'		87'		
Light buff shale—"fire clay"	1'		88'		
Gray calcareous sandy shale	1'		89'		
Black calcareous bituminous shale	8'		97'		
Dove colored shale	33'		130'		
Gray shale	18'		148'		
Light buff colored shale	9'		157'		
Pearl (light) gray micaceous sandstone	4'		161'		
Coal, Middle Rider	2'		163'		at 432 A. T.
Hard flaggy dove colored shale	11'	10"	174'	10"	
Coal		2"	175'		at 420 A. T.
Coal and shale		6"	175'	6"	
Coal	1'		176'	6"	at 418 A. T.
Light buff colored shales "fire clay"	3'	6"	180'		
Light buff colored sandy micaceous shale	3'		183'		

TEST HOLE NO. 305.

In the center of the S. line of the S. ½ of the S. E. ¼ of Section 19, T. 13 N., R. 6 E., elevation above tide is 593. '

Drift	92'	92'	
Buff colored sandstone	1'	93'	
Dove colored shales	9'	102'	
Gray shales	1'	103'	
Coal, Upper Rider	1'	104'	at 498 A. T.
Dove colored micaceous sandstone and shale	8'	112'	
Dove colored shale	10'	122'	
Gray shale	2'	124'	
Light gray—"fire clay"	7'	131'	
Dove colored shales	11'	142'	
Gray shales and bits of coal, Lower Verne	2'	144'	
Dove colored shales	11'	155'	
Harder dove colored flaggy shales	8'	163'	
Coal with some shale, Middle Rider	2'	165'	at 428 A. T.
Light shale—"fire clay"	2'	167'	
Fawn colored micaceous sandstone	13'	180'	

TEST HOLE NO. 306.

Ten rods E. from N. and S. ¼ line on the north E. and W. sub. ¼ line, N. E. ¼ of Section 32, T. 13 N., R. 6 E., elevation above tide is 600.′

Drift	102′	102′	
Buff colored sandstone	18′	120′	
Gray shale	5′	125′	
Dove colored micaceous shale	7′	132′	
Gray shale with bits of coal	1′	133′	
Dove colored shale	10′	143′	
Gray bituminous shale	1′	144′	
Dove colored shale	21′	165′	
Hard flaggy darker shales	9′	174′	
Light gray micaceous sandstone with bituminous matter	35′	209′	
Gray sandy shale	26′	235′	
Light shale "fire clay"	8′	243′	
Dove colored sandy shales	7′	250′	
Gray calcareous shales	15′	265′	
Dove colored sandy shales and bits of mica	39′	304′	
Black micaceous shale	1′	305′	
Coal, Lower coal	1′	306′	at 294 A. T.
Light gray sandstone	4′	310′	
White micaceous sandstone	15′	325′	
Gray shale	6′	331′	
Buff micaceous sandstone	10′	341′	

TEST HOLE NO. 307.

Five rods W. from Tuscola Stone Road on the north E. and W. sub. ¼ line of Section 32, T. 13 N., R. 6 E., elevation above tide is 600.′

Drift	98′	98′	
Gravel	4′	102′	
Dove colored shale	5′	107′	
Buff colored sandstone	5′	112′	
Black sandy shale and coal	3′	115′	
Dove colored shale	6′	121′	
Gray shale with bits of calcareous material	6′	127′	
Gray shale	13′	140′	
Gray sandy shale	4′	144′	
Darker gray sandy shale	6′	150′	
Dark gray shale with bits of coal	1′	151′	
Coal, Lower Verne	1′	152′	at 448 A. T.
Shale and coal with bits of calcareous material	2′	154′	
Light gray micaceous sandstone	22′	177′	
Gray sandy micaceous shale	7′	184′	
Mottled gray shale "fire clay"	3′	187′	
Buff micaceous sandstone	14′	201′	

TEST HOLE NO. 308.

In the N. W. corner of the E. ½ of the S. W. ¼ of Section 16, T. 13 N., R. 6 E., elevation above tide is 590.′

Drift	96′	96′	
Light gray micaceous sandstone	6′	102′	
Light gray micaceous sandstone, less argillaceous	7′	109′	
White micaceous sandstone	29′	138′	
Light gray micaceous sandstone with bituminous matter	2′	140′	

Buff colored shale micaceous sandstone	2′	142′	
Dove colored shale	2′	144′	
Dark gray shale with bituminous matter	1′	145′	
Dove colored sandy shales	17′	162′	
Coal, Middle Rider	1′	163′	at 427 A. T.
Buff colored micaceous sandstone	11′	174′	
Light gray micaceous sandstone	2′	176′	
White micaceous sandstone	24′	200′	

TEST HOLE NO. 309.

In the center of the S. end of the N. W. ¼ of the S. W. ¼ of Section 16, T. 13 N., R. 6 E., elevation above tide is 594.′

Drift	86′	86′	
Dove colored sandy shale	10′	96′	
White micaceous, calcareous sandstone	66′	162′	
Sandstone and coal, Middle Rider	1′	163′	at 431 A. T.
White sandy shale or fire clay with calcareous bits	6′	169′	
Light gray or buff micaceous sandstone with calcareous bits	61′	230′	
Gray sandy calcareous shale	3′	233′	
Fawn colored micaceous sandstone	1′	234′	
Gray shale	3′	237′	
White sandy slightly calcareous shale and "fire clay"	1′	238′	
Black sandy shale	1′	239′	
Gray sandy shale	24′	263′	
Fawn colored micaceous sandstone	3′	266′	
White micaceous sandstone	7′	273′	
Gray sandy micaceous shale	2′	275′	
Buff micaceous sandstone	5′	280′	

TEST HOLE NO. 310.

On the E. and W. ¼ line 40 rods E. of the N. and S. ¼ line of Section 23, T. 13 N., R. 6 E., elevation above tide is 590.′

Drift	85′	85′	
Dove colored shale with bits of calcareous material	6′	91′	
White sandy shale	3′	94′	
Dove colored shale	2′	96′	
Buff colored sandy shale	7′	103′	
White shaly sandstone	3′	106′	
Light gray shaly sandstone	1′	107′	
Dove colored shale	2′	109′	
Gray shale	1′	110′	
Light gray shaly sandstone	1′	111′	
Buff colored calcareous sandstone with bits of coal, Upper Verne	9′	120′	at 470 A. T.
Buff colored slightly calcareous sandstone	1′	121′	
Light gray sandy shale	5′	126′	
Dove colored slightly calcareous shale	4′	130′	
Gray shale	13′	143′	
Light gray sandstone	4′	147′	
Light gray sandstone	6′	153′	
Gray shale	13′	166′	
Gray sandy shale	2′	168′	
Light gray sandstone and shale	3′	171′	
Dove colored shale	7′	178′	

Gray shale	13′		191′		
Dove colored shale	9′		200′		
Gray shale	19′		219′		
Black shale	2′		221′		
Dove colored sandy shale	1′		222′		
Light gray shaly sandstone	6′		228′		
Brown sandy shale	11′		239′		
Gray shale		6″	239′	6″	
Coal, Lower Coal or Lower Rider	1′	6″	241′		at 353 A. T.
Dove colored shale	1′		242′		
Light gray sandstone with bits of shale	3′		245′		
Light gray sandstone	4′		249′		

Records from the Sage Land and Improvement Company.

Test Holes Nos. 311-331.

TEST HOLE NO. 311.

In the S. E. ¼ of the N. E. ¼ of Section 30, T. 15 N., R. 5 E., W. L. Ralston, driller. March 29, 1899, elevation above tide is 583′.

Sand	16′		16′		
Clay	22′		38′		
Sand and gravel	24′		62′		
Gray sandrock	16′		78′		
White sandrock	69′		147′		

TEST HOLE NO. 312.

In the N. W. ¼ of the N. E. ¼ of Section 30, T. 15 N., R. 5 E., elevation above tide is 583′. W. L. Ralston, driller. December 9, 1899.

Sand	18′		18′		
Clay	30′		48′		
Sand	12′		60′		
Gray sandrock	27′		87′		
White sandrock	53′		140′		
Blue shale	7′		147′		
Light gray rock	17′		164′		
White sandrock	4′		168′		
Dark gray rock	2′	8″	170′	8″	
Black slate	1′	4″	172′		
White sandrock	1′		173′		

TEST HOLE NO. 313.

In the N. E. ¼ of the S. W. ¼ of Section 19, T. 15 N., R. 5 E., elevation above tide is 583′. W. L. Ralston, driller. January 12, 1900.

Sand	16′		16′		
Clay	44′		60′		
Sand	4′		64′		
Gray sandrock	25′	5″	89′	5″	
Coal, Upper Rider		7″	90′		at 493 A. T.
White sandrock	110′		200′		
Gray shale	16′		216′		
White sandrock	46′		262′		
Black slate	12′		274′		
Coal, Lower Rider	0′	5″	274′	5″	at 309 A. T.
Sandrock	1′		275′	5″	
Gray shale	13′		288′	5″	
Blue shale	12′		300′	5″	
White sandrock	4′		304′	5″	

TEST HOLE NO. 314.

In the S. W. ¼ of the N. E. ¼ of Section 19, T. 15 N., R. 5 E., elevation above tide is 583′. W. L. Ralston, driller, February 15, 1900.

Sand	19′		19′		
Clay	62′		81′		
Sandrock	6′		87′		
Gray shale	26′		113′		
Sandrock	4′		117′		
Gray shale	12′		129′		
Sandrock	7′		136′		
Gray shale	6′		142′		
Sandrock	48′		190′		
Gray rock	16′		206′		
Sandrock	39′		245′		
Gray shale	11′		256′		
Black slate	8′		264′		
Gray rock	9′		273′		
Sandrock	17′		290′		
Black slate	7′		297′		
Gray rock	4′		301′		
Gray shale	7′		308′		
Gray sandrock	12′		320′		
Gray shale	10′		330′		
Black slate	1′	6″	331′	6″	
Gray shale	3′		334′	6″	
White sandrock	5′		339′	6″	

TEST HOLE NO. 315.

On the east side of the S. E. ¼ of the N. E. ¼ of Section 24, T. 15 N., R. 4 E., elevation above tide is 582′. W. L. Ralston, driller. March 5, 1900.

Sand	16′		16′		
Clay	52′		68′		
Gray shale	7′		75′		
Salzburg coal		3″	75′	3″	at 507 A. T.
Gray shale	43′		118′	3″	
Sandrock	12′		130′	3″	
Gray shale	16′		146′	3″	
White sandrock	14′		160′	3″	
Gray sandrock	49′		209′	3″	

TEST HOLE NO. 316.

In the S. E. ¼ of the S. W. ¼ of Section 24, T. 15 N., R. 4 E., elevation above tide is 585′. A. J. Wampler, driller, August 15, 1899.

Sand	10′		10′		
Clay	61′		71′		
Gray shale	17′		88″		
Black slate	1′		89′		
Gray shale	57′		146′		
Coal		2″	146′	2″	at 439 A. T.
Sandrock	47′	7″	193′	9″	

TEST HOLE NO. 317.

In the N. W. ¼ of the N. W. ¼ of Section 24, T. 15 N., R. 4 E., A. J. Wampler, driller, August 24, 1899, elevation above tide is 585′.

Clay	61′	61′	
Sandrock	10′	71′	
Gray shale	6′	77′	
Fire clay	1′	78′	
Gray shale	3′	81′	

Slate	2′		83′		
Salzburg coal		6″	83′	6″	at 502 A. T.
Slate		6″	84′		
Fire clay	3′	6″	87′	6″	
Slate		6″	88′		
Gray shale	3′		91′		
Slate	1′	6″	92′	6″	
Gray shale	2′	6″	95′		
Fire clay	1′		96′		
Gray shale	37′		133′		
Fire clay	3′		136′		
Sandrock	1′		137′		
Fire clay	1′		138′		
Sandrock	23′		161′		
Gray shale	2′		163′		
Sandrock	2′		165′		
Gray shale	3′		168′		
Sandrock	7′		175′		

TEST HOLE NO. 318.

In the N. E. ¼ of the N. W. ¼ of Section 24, T. 15 N., R. 4 E., elevation above tide is 584′. A. J. Wampler, driller, September 8, 1899.

Sand	6′		6′		
Clay	62′		68′		
Gray shale	26′	6″	94′	6″	
Slate		9″	95′	3″	
Coal, Upper Rider		3″	95′	6″	at 489 A. T.
Gray shale	44′	6″	140′		
Sandrock	18′		158′		
Gray shale	20′		178′		
Sandrock	6′		184′		
Gray shale	8′		192′		
Sandrock	8′		200′		

TEST HOLE NO. 319.

In the S. W. ¼ of the N. E. ¼ of Section 24, T. 15 N., R. 4 E., elevation above tide is 584′. A. J. Wampler, driller, September 19, 1899.

Clay	58′		58′		
Gray shale	1′		59′		
Salzburg coal and slate Rider	1′		60′		at 524 A. T.
Gray shale	38′		98′		
Sandrock	3′		101′		
Gray shale	9′		110′		
Sandrock	12′		122′		
Gray shale	2′		124′		
Sandrock	2′		126′		
Gray shale	9′		135′		
Sandrock	55′		190′		
Gray shale	10′		200′		

TEST HOLE NO. 320.

In the S. W. part of the N. E. ¼ of the S. E. ¼ of Section 24, T. 15 N., R. 4 E., elevation above tide is 583′. A. J. Wampler, driller, September 20, 1899.

Sand	20′		20′		
Clay	45′		65′		
Gray shale	21′		86′		
Slate		3″	86′	3″	
Salzburg coal		7″	86′	10″	at 496 A. T.
Slate	1′	8″	88′	6″	

Fire clay	3′	6″	92′	
Gray shale	1′		93′	
Fire clay	6′		99′	
Gray shale	13′		112′	
Sandrock	1′	6″	113′	6″
Gray shale	4′	6″	118′	
Sandrock	10′		128′	
Gray shale	25′		153′	
Sandrock	17′		170′	

TEST HOLE NO. 321.

In the N. W. part of the S. E. ¼ of the S. E. ¼ of Section 24, T. 15 N., R. 4 E., elevation above tide is 583′. A. J. Wampler, driller, October 9, 1899.

Sand	18′		18′	
Clay	45′		63′	
Gray shale	25′		88′	
Slate		8″	88′	8″
Salzburg coal		10″	89′	6″ at 494 A. T.
Gray shale	3′	6″	93′	
Slate		3″	93′	3″
Coal, Upper Rider		3″	93′	6″ at 490 A. T.
Slate		6″	94′	
Fire clay	4′		98′	
Gray shale	48′		146′	
Sandrock	1′		147′	
Gray shale	14′		161′	
Sandrock	9′		170′	

TEST HOLE NO. 322.

In the S. E. part of the N. E. ¼ of the S. E. ¼ of Section 24, T. 15 N., R. 4 E., A. J. Wampler, driller, October 16, 1899. The elevation above tide is 583′.

Sand	25′		25′	
Clay	35′		60′	
Sand	4′		64′	
Gray shale	15′		79′	
Salzburg coal		4″	79′	4″ at 504 A. T.
Gray shale	14′	8″	94′	
Fire clay	4′		98′	
Gray shale	1′		99′	
Slate		8″	99′	8″
Coal, Upper Rider		2″	99′	10″ at 483 A. T.
Gray shale	15′	2″	115′	
Sandrock	17′		132′	
Gray shale	2′		134′	
Sandrock	2′		136′	
Gray shale	4′		140′	
Sandrock	3′		143′	
Gray shale	7′		150′	

TEST HOLE NO. 323.

In the S. W. ¼ of the S. E. ¼ of Section 24, T. 15 N., R. 4 E. The elevation above tide is 585′. A. J. Wampler, driller, October 18, 1899.

Sand	16′		16′	
Clay	52′		68′	
Gray shale	21′		89′	
Salzburg coal		2″	89′	2″ at 496 A. T.
Gray shale	1′	10″	91′	

Coal	Riders of Upper Verne		2″	91′	2″	at 491 A. T.
Gray shale			10″	92′		
Coal			2″	92′	2″	at 490 A. T.
Gray shale			4″	92′	6″	
Coal			2″	92′	8″	at 489 A. T.
Gray shale		3′		95′	8″	
Slate			3″	95′	11″	
Gray shale			11″	96′	10″	
Slate			2″	97′		
Fire clay		1′		98′		
Gray shale		10′		108′		
Slate			4″	108′	4″	
Fire clay		2′	8″	111′		
Gray shale		5′		116′		
Sandrock		4′		120′		

TEST HOLE NO. 324.

In the S. W. part of the S. W. ¼ of the S. W. ¼ of Section 19, T. 15 N., R. 5 E., elevation above tide is 583′. A. J. Wampler, driller, October 23, 1899.

Sand	18′		18′		
Clay	40′		58′		
Gray shale	22′		80′		
Slate	2′		82′		
Gray shale	2′	6″	84′	6″	
Slate		6″	85′		
Salzburg coal		10″	85′	10″	at 497 A. T.
Gray shale	27′	2″	113′		
Sandrock	13′		126′		
Blue shale	2′		128′		
Sandrock	3′		131′		
Gray shale	5′		136′		
Sandrock	8′		144′		
Gray shale	2′		146′		
Sandrock	3′		149′		
Blue shale	1′		150′		

TEST HOLE NO. 325.

Near the center of the N. W. ¼ of Section 13, T. 15 N., R. 4 E., elevation above tide is 582′. A. J. Wampler, driller, November 1, 1899.

Sand	16′		16′		
Clay	58′		74′		
Gray shale	15′		89′		
Fire clay	7′		96′		
Sandrock	2′		98′		
Fire clay	3′		101′		
Sandrock	9′		110′		
Gray shale	12′		122′		
Sandrock	4′		126′		
Gray shale	8′		134′		
Sandrock	7′		141′		
Gray shale	9′		150′		

TEST HOLE NO. 326.

In the N. E. ¼ of the N. W. ¼ of Section 13, T. 15 N., R. 4 E., elevation above tide is 583′. A. J. Wampler, driller, November 25, 1899.

Sand	7′		7′	
Clay	58′		65′	
Gray shale	14′		79′	
Slate	1′	6″	80′	6″

Gray shale	16′		96′	6″	
Fire clay	6′		102′	6″	
Gray shale	5′	6″	108′		
Sandrock	8′		116′		
Fire clay		6″	116′	6″	
Sandrock	23′	6″	140′		

TEST HOLE NO. 327.

In the S. E. part of the S. W. ¼ of the N. E. ¼ of Section 13, T. 15 N., R. 4 E., elevation above tide is 583′. A. J. Wampler, driller, December 14, 1899.

Sand	10′		10′		
Clay	57′		67′		
Gray shale	3′		70′		
Sandrock	2′		72′		
Gray shale	9′	6″	81′	6″	
Slate		6″	82′		
Salzburg coal	1′	1″	83′	1″	at 500 A. T.
Gray shale	10′	11″	94′		
Slate		6″	94′	6″	
Gray shale	35′	6″	130′		
Sandrock	5′		135′		
Gray shale	5′		140′		
Sandrock	20′		160′		

TEST HOLE NO. 328.

In the S. E. part of the N. E. ¼ of the S. E. ¼ of Section 13, T. 15 N., R. 4 E., elevation above tide is 585′. A. J. Wampler, driller.

Sand	12′		12′		
Clay	56′		68′		
Gray shale	6′		74′		
Slate		3″	74′	3″	
Gray shale	1′	9″	76′		
Fire clay	1′		77′		
Gray shale	5′		82′		
Fire clay	1′	6″	83′	6″	
Gray shale	38′	6″	122′		
Slate	1′	1″	123′	1″	
Gray shale	16′	11″	140′		
Sandrock	123′		263′		
Gray shale	34′		297′		
Sandrock	3′		300′		
Gray rock	3′		303′		
Gray shale	25′		328′		
Blue shale	3′		331′		
Gray rock		6″	331′	6″	
Slate		2″	331′	8″	
Bangor coal Rider	1′		332′	8″	at 252 A. T.
Slate		4″	333′		
Sandrock	3′		336′		
Gray shale	16′		352′		
Sandrock	2′		354′		

TEST HOLE NO. 329.

In the S. W. part of the S. W. ¼ of the S. E. ¼ of Section 13, T. 15 N., R. 4 E., elevation above tide is 583′. A. J. Wampler, driller, March, 1900.

Sand	8′	8′	
Clay	59′	67′	
Gray shale	25′	92′	
Sandrock	148′	240′	
Gray shale	31′	271′	
Sandrock	7′	278′	

TEST HOLE NO. 330.

In the W. ½ of the S. W. ¼ of Section 17, T. 14 N., R. 5 E. In Bangor township; Jennison, owner. Theodore Archambeau, driller, elevation above tide is 598′.

Clay	85′		85′		
Gravel	3′		88′		
Black slate	2′		90′		
White sandrock	3′		93′		
Black sandrock	4′		97′		
Gray sandrock	3′		100′		
Black slate		10″	100′	10″	
Coal, Upper Rider		4″	111′	2″	at 487 A. T.
Sandy shale	21′	10″	133′		
Black slate	3′		136′		
White sandrock	11′	5″	147′	5″	
Coal, Lower Verne	1′	11″	149′	4″	at 449 A. T.
Gray shale	15′	8″	165′		
Black slate	5′		170′		
White sandrock	6′		176′		

TEST HOLE NO. 331.

In the N. W. ¼ of the N. E. ¼ of Section 18, T. 14 N., R. 5 E., elevation above tide is 594.′ Theodore Archambeau, driller.

Clay	83′		83′		
Sand	2′		85′		
Sandrock	1′		86′		
Gray slate	2′		88′		
Black slate	1′		89′		

Miscellaneous Records.

Test Hole Nos. 332-361.

TEST HOLE NO. 332.

Bay Coal Mining Company. No. 2 shaft in the S. E. ¼, Section 4, T. 13 N., R. 4 E., elevation 605′ A. T.

Clay most of the way to the bed rock at	111′		111′		
Eleven feet of black shale above coal at	139′		139′		
Coal 3 feet thick, Upper Verne	3′		142′		at 463 A. T.
Gray sandstone below the coal	....		....		

TEST HOLE NO. 333.

Central Mine shaft record. Elevation, A. T. 594′. The S. E. ¼ of the S. E. ¼ of Section 25, T. 14 N., R. 4 E.

Clay	75′		75′		
Sand, gravel and boulders	5′	5″	80′	5″	
Soft shale	7′	8″	88′	1″	
Salzburg coal	2′	8″	90′	9″	at 503 A. T.
Slate	5′		95′	9″	
Sandstone	11′	9″	107′	2″	
Soft black slate	5′		112′	2″	
Hard slate	2′	10″	115′		
Coal, Upper Verne	2′	8″	117′	8″	at 476 A. T.
Fire clay	3′	5″	121′	1″	
Soft blue slate	10′		131′	1″	

TEST HOLE NO. 334.

Hecla shaft record. Summer of 1902. The N. W. ¼ of the S. E. ¼ of Section 2, T. 13 N., R. 4 E., elevation above tide is 598.′

Sandy loam	2′		2′	
Clay subsoil	8′		10′	
Brown clay	20′		30′	
Blue clay	14′		44′	
Brown sandy clay and boulders	20′		64′	
Blue clay and boulders	13′		77′	
Blue clay and boulders	6′		83′	
Quicksand with fragments of trees	2′		85′	
Rotten slate	9′		94′	
Light sandrock	4′		98′	
Coal and slate, Upper Verne Rider	2′	4″	100′	4″ at 498 A. T.
Fire clay	1′	8″	102′	
Slate	3′		105′	
Coal, Upper Verne	2′	4″	107′	4″ at 491 A. T.
Light colored sandstone	12′	8″	120′	
Slate	6′		126′	
Dark black shale	5′		131′	

TEST HOLE NO. 335.

Wenona Beach Coal Company. The N. W. ¼ of Section 4, T. 14 N., R. 5 E. Elevation above tide, 583′.

Clay	74′		74′	
Sandrock	9′		83′	
Shale	37′		120′	
Coal	3′	6″		
Slate — Upper Verne		10″		
Coal	3′		127′	5″ at 456 A. T.
Fire clay	8′	9″	135′	5″
White sandstone	....		....	

TEST HOLE NO. 336.

Valley Coal Co. shaft, 583′ above tide. In the S. E. ¼ of the N. E. ¼ of Section 1, T. 13 N., R. 4 E.

Clay	83′		83′	
Coal, Upper Rider		4″	83′	4″ at 500 A. T.
Light fire clay	3′		86′	4″
Dark fire clay	4′		90′	4″
Fire clay, shale	23′		113′	4″
Coal, Upper Verne	4′		117′	4″ at 466 A. T.
Fire clay	3′		120′	4″

TEST HOLE NO. 337.

In the N. W. ¼ of the N. E. ¼ of Section 25, T. 14 N., R. 4 E., elevation above tide is 597′.

Clay	84′		84′	
Blue shale	2′		86′	
Black rock	10′		96′	
Gray rock	14′		110′	
Black rock	11′		121′	
Gray rock	8′		129′	
Coal, Upper Verne		8″	129′	8″ at 467 A. T.
Gray shale	7′	8″	137′	4″
Slate		8″	138′	
Gray shale	23′		160′	
Dark shale	17′		177′	
Black slate	6′		183′	
Fire clay		6″	183′	6″
Sandrock	2′		185′	6″

TEST HOLE NO. 338.

N. part of the S. E. ¼ of the N. E. ¼ of Section 25, T. 14 N., R. 4 E., elevation above tide is 597′. Theodore Archambeau, driller.

Gravelly clay	50′		50′		
Gray clay	30′		80′		
Gravelly clay	9′		89′		
Gray shale	3′		92′		
Gray slate	4′		96′		
Sandy shale	2′		98′		
Black slate	3′		101′		
Dark sandrock	4′		105′		
White sandrock	6′		111′		
Gray sandrock	7′		118′		
Gray slate	12′		130′		
Bone coal, Upper Verne		5″	130′	5″	at 467 A. T.
Dark gray rock	16′		146′	5″	

TEST HOLE NO. 339.

In the N. ½ of the N. E. ¼ of Section 15, T. 14 N., R. 4 E., in river bed. Theodore Archambeau, driller.

Muck	8′	8′	
Sand	6′	14′	
Clay and gravel	32′	46′	
Sand	10′	56′	
Gravel	18′	74′	
With water flowing above surface—strong 5′+ ground— hard—sulphur and iron. Sand.			

TEST HOLE NO. 340.

In the center of Section 4, T. 13 N., R. 4 E., elevation above tide is 609′. W. L. Ralston, driller.

Clay	90′		90′		
Sand	18′		108′		
Blue shale	6′	9″	114′	9″	
Coal		7″	115′	4″	at 494 A. T.
Gray shale	11′	8″	127′		
Coal, Upper Rider		10″	127′	10″	at 481 A. T.
Coal and slate		7″	128′	5″	
Gray shale	9′	7″	138′		
Coal, Upper Verne	1′	10″	139′	10″	at 469 A. T.
Gray shale	14′	2″	154′		
Slate	2′		156′		
Coal, Lower Verne	2′	7″	158′	7″	at 450 A. T.
Gray shale	7′	3″	165′	10″	
Coal, Middle Rider		2″	166′		at 443 A. T.
Gray shale	5′		171′		
Coal, Saginaw coal?		3″	171′	3″	at 438 A. T.
White shale	7′	9″	179′		
Sandrock (white)	12′		191′		
Gray shale	22′		213′		
White sandrock	8′		221′		
Gray shale	19′		240′		
White sandrock	16′		256′		
Slate	1′		257′		
Sandrock	12′		269′		
Blue shale	11′		280′		
Sandrock	3′		283′		
Gray shale	10′	4″	293′	4″	
Chip slate		8″	294′		

White sandrock	13′		307′		
Blue shale	37′		344′		
Gray shale	4′		348′		
Black shale	5′		353′		
Chip slate	1′		354′		
White shale	2′		356′		
Gray rock	10′		366′		
Black shale	22′		388′		
White sandrock	21′		409′		
Gray shale	20′		429′		
Conglomerate rock	4′		433′		
Gray shale	11′		444′		
Conglomerate rock	6′		450′		

TEST HOLE NO. 341.

N. W. corner of Section 14, T. 14 N., R. 4 E. Fred Pierson, owner; W. L. Ralston, driller, elevation above tide is 601′.

Clay	60′		60′		
Sand	44′		104′		
Blue shale	11′		115′		
Gray shale	15′		130′		
Gray slate	1′	9″	131′	9″	
Gray rock	24′	3″	156′		
White sandrock	5′		161′		
Black slate	2′		163′		
Fire clay	2′		165′		
Gray rock	7′		172′		
White sandrock	25′		197′		
Gray rock	15′	5″	212′	5″	
Chip slate		7″	213′		
Gray shale	9′		222′		
Coal, Lower Rider		3″	222′	3″	at 379 A. T.
White sandrock	2′	9″	225′		

TEST HOLE NO. 342.

In the N. ½ of the S. E. ¼ of Section 11, T. 14 N., R. 4 E. Sarah Phillips, owner; W. L. Ralston, driller, elevation above tide is 597′.

Clay	90′		90′		
Sand	19′		109′		
Blue shale	5′		114′		
Gray shale	6′		120′		
Coal, Upper Rider		3″	120′	3″	at 477 A. T.
Fire clay	2′	9″	123′		
Gray sandrock	7′		130′		
Gray slate	12′	4″	142′	4″	
Gray rock	6′	8″	149′		
White sandrock	17′		166′		
Gray slate	7′		173′		
Black slate		5″	173′	5″	
Coal, Saginaw coal	1′	7″	175′		at 422 A. T.
Fire clay	2′		177′		
White sandrock	3′		180′		
Blue shale	40′		220′		
White sandrock	3′	5″	223′	5″	
Chip slate		7″	224′		
Gray shale	16′		240′		
Black shale	9′		249′		
Gray rock	8′		257′		
Fire clay	3′		260′		
White sandrock	2′		262′		

TEST HOLE NO. 343.

In the S. ½ of the S. W. ¼ of Section 11, T. 14 N., R. 4 E. Theodore Archambeau, owner; W. L. Ralston, driller, elevation above tide is 600′.

Clay	90′		90′	
Sand	30′		120′	
Soapstone	4′		124′	
Gray shale	9′		133′	
Coal, Upper Verne		10″	133′ 10″	at 466 A. T.
Gray shale	15′		148′ 10″	
Gray slate	1′	2″	150′	
Light gray rock	5′		155′	
White sandrock	6′		161′	
Gray shale	10′		171′	
Slate and coal, Saginaw coal	1′		172′	at 428 A. T.
Gray slate	7′		179′	
White sandrock	7′		186′	

TEST HOLE NO. 344.

Section 12, T. 14 N., R. 5 E. (S. ½ of N. W. ¼). Mr. Penniman. Commenced December 1, 1897, elevation above tide is 582′.

To the rock 80 feet	80′		80′	
Lime	20′		100′	
Coal, Upper Verne	4′		104′	at 478 A. T.
Sandrock	15′		119′	
Shale	31′		150′	
Coal, Lower Verne	3′		153′	at 429 A. T.
Sandrock	6′		159′	
Lime rock	5′		164′	
Shale	3′		167′	
Coal, Middle Rider	2′		169′	at 413 A. T.
Lime rock	12′		181′	
Plaster[1]	15′		196′	
Salt rock	10′		206′	
Lime	2′		208′	

TEST HOLE NO. 345.

In the S. ½ of the N. W. ¼ of Section 12, T. 14 N., R. 5 E. Mr. Penniman, owner. Commenced, December 28, 1897, elevation above tide is 582′.

To rock	80′		80′	
Lime	40′		120′	

Lost our drill and abandoned hole.

TEST HOLE NO. 346.

In the S. ½ of the N. W. ¼ of Section 12, T. 14 N., R. 5 E. Commenced January 10, 1898, elevation above tide is 582′.

To rock	82′		82′	
Lime	20′		102′	
Coal, Upper Verne	1′		103′	at 479 A. T.
Sandrock	10′		113′	
Plaster[2]	1′		114′	
Lime rock	6′		120′	
Shale	10′		130′	
Lime rock	10′		140′	
Coal, Middle Rider	2′		142′	at 440 A. T.
Sandrock	6′		148′	
Lime	10′		158′	
Shale	2′		160′	
Lime rock	12′		172′	
Plaster[2]	4′	6″	176′ 6″	

[1] Probably not rock salt or gypsum.

TEST HOLE NO. 347.

In the S. ½ of the N. W. ¼ of Section 12, T. 14 N., R. 5 E. Mr. Penniman, owner. Commenced February 17, 1898, elevation above tide is 582′.

To the rock	80′		80′		
Lime	64′		144′		
Shale	4′	6″	148′	6″	
Coal, Middle Rider		6″	149′		at 433 A. T.
Shale	7′		156′		
Plaster[2]	3′		159′		
Sandrock	2′		161′		
Lime	3′		164′		

TEST HOLE NO. 348.

In the S. ½ of the N. W. ¼ of Section 12, T. 14 N., R. 5 E. Mr. Penniman, owner. Commenced March 7, 1898, elevation above tide is 582′.

To the rock	82′		82′		
Lime	15′		97′		
Coal, Upper Verne	1′		98′		at 484 A. T.
Sandrock	10′		108′		
Shale	6′		114′		
Lime rock	5′		119′		
Sandrock	5′		124′		
Shale	20′		144′		
Coal, Middle Rider	2′		146′		at 436 A. T.
Sandrock	3′		149′		
Lime rock	3′		152′		
Shale	22′		174′		
Lime rock	3′		177′		
Shale	14′		191′		
Lime rock	7′		198′		
Coal, Saginaw coal	2′		200′		at 382 A. T.
Lime rock	4′		204′		

TEST HOLE NO. 349.

In the S. ½ of the N. W. ¼ of Section 12, T. 14 N., R. 5 E. Mr. Penniman, owner. Commenced November 14, 1898, elevation above tide is 582′.

To rock	82′		82′		
Lime	30′		112′		
Shale	12′		124′		
Lime rock	21′		145′		
Shale	20′		165′		
Coal, Middle Rider	1′		166′		at 416 A. T.
Shale	5′		171′		
Lime rock	21′		192′		
Shale	14′		206′		
Coal, Saginaw coal	3′	2″	209′	2″	at 373 A. T.
Fire clay	3′	10″	213′		

TEST HOLE NO. 350.

In the S. ½ of the N. W. ¼ of Section 12, T. 14 N., R. 5 E. Mr. Penniman, owner. Commenced December 21, 1898, elevation above tide is 582′.

To the rock	80′		80′		
Lime	50′	10″	130′	10″	
Shale		8″	131′	6″	
Coal, Lower Verne	3′	5″	134′	11″	at 447 A. T.
Lime rock	2′		136′	11″	
Fire clay	3′		139′	11″	
Lime rock	8′	6″	148′	5″	

[2] Probably not rock salt or gypsum.

Shale	12′		160′	5″	
Coal, Middle Rider	2′		162′	5″	at 420 A. T.
Shale	20′		182′	5″	
Flint rock	1′		183′	5″	
Lime	3′		186′	5″	
Shale and coal mixed, Saginaw coal	8′		194′	5″	at 388 A. T.

TEST HOLE NO. 351.

In the S. ½ of the N. W. ¼ of Section 12, T. 14 N., R. 5 E. Mr. Penniman, owner. Commenced January 4, 1899, elevation above tide is 582′.

To the rock	75′		75′		
Sandstone	51′		126′		
Coal, Lower Verne	2′		128′		at 454 A. T.
Lime	7′		135′		
Shale	31′		166′		
Lime rock	19′		185′		
Shale	15′		200′		

TEST HOLE NO. 352.

In the S. ½ of the N. E. ¼ of Section 6, T. 13 N., R. 6 E., elevation above tide is 598′.

Clay	90′		90′		
Hardpan	4′		94′		
Sandy gravel	3′		97′		
Black slate	8′		105′		
Fire clay	4′	6″	109′	6″	
Black slate	5′		114′	6″	
Fire clay	5′	6″	120′		
Gray slate	2′		122′		
Sandrock	3′		125′		
Fire clay	2′	6″	127′	6″	
Gray slate	7′	6″	135′		
Black slate		6″	135′	6″	
Coal, Upper Verne	1′	5″	136′	11″	at 461 A. T.
Fire clay	5′		141′	11″	
Gray slate	11′		152′	11″	
Black slate	1′		153′	11″	
Fire clay	4′		157′	11″	
Gray slate	5′		162′	11″	
Coal, Lower Verne		5″	163′	4″	at 435 A. T.
Gray slate	1′	6″	164′	10″	
Gray shale	3′		167′	10″	
Gray slate	7′		173′	10″	
Black slate	1′		174′	10′	
Coal, Middle Rider		2″	175′		at 423 A. T.
Fire clay	1′		176′		
Coal		7″	176′	7″	at 421 A. T.
Fire clay	1′		177′	7″	
Sand rock	1′	6″	179′	1″	
Gray slate	3′		182′	1″	
Black slate		6″	182′	7″	
Sandrock	15′		197′	7″	
Gray slate	2′		199′	7″	
Black slate	3′		202′	7″	
Coal, Saginaw coal	1′	1″	203′	8″	at 395 A. T.
Gray slate	28′		231′	8″	
Sandrock	4′		235′	8″	

TEST HOLE NO. 353.

In the N. W. ¼ of the N. E. ¼ of Section 6, T. 13 N., R. 6 E., elevation above tide, 596′.

Clay	92′		92′		
Fire clay	2′		94′		
Sandrock	7′		101′		
Gray shale	6′	6″	107′	6″	
Gray slate	3′		110′	6″	
Black slate	9′	6″	120′		
Fire clay	4′		124′		
Gray slate	5′		129′		
Black slate	6′		135′		
Coal, Upper Verne	1′	1″	136′	1″	at 460 A. T.
Black slate		6″	136′	7″	
Fire clay	4′		140′	7″	
Gray slate	1′		141′	7″	
Sandrock	3′	6″	145′	1″	
Gray slate	24′		169′	1″	
Black slate	1′		170′	1″	
Coal, Middle Rider	2′		172′	1″	at 424 A. T.
Fire clay	7′		179′	1″	
Sandrock	3′		182′	1″	
Gray slate	3′		185′	1″	
Fire clay	2′	6″	187′	7″	
Gray slate	1′	6″	189′	1″	
Coal, Saginaw coal		7″	189′	8″	at 406 A. T.
Sandrock	6′	5″	196′	1″	

TEST HOLE NO. 354.

In the S. W. corner of Section 4, T. 16 N., R. 3 E. F. J. Tromble, operator, elevation above tide is 665′.

Clay	104′		104′		
Sand	6′		110′		
Plastic clay	17′		127′		
Gray shale	13′		140′		
Slate	1′		141′		
Coal	2′	8″	143′	8″	at 522 A. T.
Slate (Upper Verne?)		2″	143′	10″	
Coal		10″	144′	8″	at 521 A. T.
Gray shale	5′		149′	8″	
Slate	1′		150′	8″	
Coal, Lower Verne?	2′	2″	152′	10″	at 512 A. T.
Slate		4″	153′	2″	
Gray shale to	31′	10″	185′		

TEST HOLE NO. 355.

In the S. E. ¼ of Section 10, T. 17 N., R. 3 E. Land of J. Mansfield. Average elevation is 660′ above tide[1].

Clay	80′		80′		
Sand	4′		84′		
Hardpan	8′		92′		
Black shale	2′		94′		
Blue shale	20′		114′		
Gray shale	18′		132′		
Black shale	2′		134′		
Coal, Verne coal?		6″	134½′		at 526 A. T.
Blue shale	15′	6″	150′		
Gray shale	10′		160′		
Sandrock	5′		165′		
Coal, Middle Rider?		5″	165′	5″	at 495 A. T.

[1] See Mich. Geol. Sur. Vol. VIII, pt. 2, pp. 98, 99.

Black shale	9′	6″	174′	11″	
Coal, Saginaw coal?		6″	175′	5″	at 485 A. T.
Blue shale	10′		185′	5″	

TEST HOLE NO. 356.

In the S. E. ¼ of Section 10, T. 17 N., R. 3 E. Land of J. Mansfield. Average elevation above tide is 660′.

Clay	82′		82′		
Hardpan	9′		91′		
Black shale	1′	6″	92′	6″	
Blue shale	15′		107′	6″	
Hardpan	15′	6″	123′		
Sandrock	8′		131′		
Hardpan	10′		141′		
Sandrock	40′	6″	181′	6″	
Coal	11′	5″	182′	6″	at 477 A. T.
Blue shale	2′		184′	6″	
Sandrock		6″	185′		
Coal, Saginaw coal		2″	185′	2″	at 475 A. T.
Blue shale	3′		188′	2″	
Sandrock	6′		194′	2″	
Blue shale	1′		195′	2″	
Sandrock	....		....		

TEST HOLE NO. 357.

In the S. E. ¼ of Section 10, T. 17 N., R. 3 E. Land of J. Mansfield. Average elevation above tide is 660′.

Clay	36′		36′		
Gravel	1′		37′		
Red gravel	1′		38′		
Clay	52′		90′		
Black shale	2′		92′		
Hardpan	4′		96′		
Black shale	3′		99′		
Slate rock	4′		103′		
White shale	3′		106′		
Blue shale	21′		127′		
Black shale	2′	9″	129′	9″	
Coal, Verne coal?		8″	130′	5″	at 530 A. T.
Blue shale	25′	7″	156′		
Sandrock	24′		180′		
Coal, Saginaw coal		3″	180′	3″	at 480 A. T.
Sandrock	5′		185′	3″	

TEST HOLE NO. 358.

Five and one-half miles due west of Lengsville, Section 26, T. 16 N., R. 3 E, elevation above tide is 630′.

Muck at surface.	
Clay to	80′
Stones and gravel	
Hardpan to	135′
Mainly sandstone to	300′

TEST HOLE NO. 359.

Record of hole for N. B. Bradley with Bullock Diamond Core Drill (3-inch) near Bay City, Mich. (See T. 14 N., R. 6 E., near head waters of Quanicassee,) elevation above tide is 583′.

Date, 1889.	Hours worked.	Formations.	Amount drilled.		Core saved.	
6/7 to 6/13		Driving casing	80′	(Boulder core) 4′	6″	
6/15	10	Drilling and churning	5′	85′ 1′		
6/17	10	Drilling and churning	3′	88′ 2′		
6/18	10	Drilling with bit	17′	105′ 10′		
6/19	10	Drilling with bit	15′	120′ 11′		
6/20	10	Drilling—pipe	10′	130′ 8′		
6/21	10	Dark shale	10′	140′ 8′		
		Light shale	3′	143′ 2′		
6/22	10	Sandstone	12′	155′ 10′		
		Dark shale	3′	158′ 2′		
		Sandstone	3′	161′ 2′		
6/24	10	Sand and shale	12′	173′ 10′		
6/25	10	Sandstone	6′	179′ 4′		
		Black shale	4′	183′ 3′		
		Gray slate rock	8′	191′ 7′		
6/26	10	Gray slate rock	4′	195′ 3′		
		Black shale	4′	199′ 3′		
		Black shale and sand	9′	208′ 8′		
		Drove 7 ft. 4″ pipe.				
6/27	10	Black shale and sandstone	7′	215′ 6′	6″	
		Sandstone	2′	217′ 2′		
6/28	10	Sandstone mixed	13′	230′ 12′	6″	
6/29	10	Black shale and fire clay	7′	237′ 6′		
7/1	10	Black shale	3′	240′		
		Fire clay	3′	243′ 13′		
		Sand and shale	5′	248′		
		Dark shale	2′	250′		
7/2	10	Dark shale	6′	256′		
		Coal, Lower Rider	1′	257′		at 326 A. T.
		Sand, white mixed	4′	261′		
		Fire clay	5′	266′ 16′		
7/3	10	Dark shale	18′	284′ 18′		
7/4	10	Dark shale	8′	292′		
		Coal, Lower coal	1′	293′		at 290 A. T.
		Dark shale	2′	295′		
		Sandstone	8′ 9″	303′ 9″ 19′		
7/5	10	Fire clay and shale	4′	307′ 9″		
		Coal	6″	308′ 3″		4″at 275 A. T.
		Sand and shale	6′	314′ 3″ 11′		
7/6	10	Black shale	5′ 6″	319′ 9″		
		Black shale and clay	4′	323′ 9″		
7/8	10	Black jack	3′	326′ 9″		
		Bangor coal Rider	6″	327′ 3″		at 256 A. T.
		Soft white clay	5′ 6″	332′ 9″ 8′		
7/9	10	Black shale	10′	342′ 9″		
7/10	10	Sand and shale mixed	3′	345′ 9″ 12′		
7/10	10	Dark shale	11′	353′ 9″ 10′		
		Black jack	3′	356′ 9″		
		Bangor coal	1′	360′ 9″		at 222 A. T.
		White sandstone	3′	363′ 9″		
7/13	10	Blue shale and sand. Top of Parma?	3′	366′ 9″ 2′		
		Iron pyrites	1′	367′ 9″		
		Blue sand with grit	6′	373′ 9″ 9′		
7/15	10	Sand	13′	386′ 9″ 10′		
7/16	10	Sandstone pins	20′	406′ 9″ 12′		

7/17	10	Same	20′	426′	9″	12′
7/18	10	Hard quartz	23′	449′	9″	16′
7/19 7/20	10	Setting bit and replacing rods.				
7/22	10	Sandstone	10′	459′	9″	7′
7/23 7/24	10	Sandstone	4′	463′	9″	3′
7/26		Repairing pump				
7/27	10	Sandstone	10′	473′	9″	9′
7/29	10	Limestone quartz	10′	483′	9″	9′
7,30	10	Same	12′	495′	9″	11′

TEST HOLE NO. 360.

One hundred feet west of the N. and S. ¼ line of Section 34, and 5′ north of the Pinconning & Glencoe R. R., T. 17 N., R. 3 E., elevation above tide is 650′.

Sand	6′		6′		
Clay and gravel	102′		108′		
Hard sandy fire clay	13′		121′		
Argillaceous sandrock	1′		122′		
Light blue shale	13′	6″	135′	6″	
Coal, Verne coal	1′	1″	136′	7″	at 513 A. T.
Sandy fire clay	8′	11″	145′	6″	

TEST HOLE NO. 361.

Near the N. and S. ¼ line of Section 33, T. 17 N., R. 3 E., elevation above tide is 660′.

Soil		8″		8″	
Sand	7′	4″	8′	0″	
Gray clay	42′		50′		
Clay with blue streaks	11′		61′		
Clay fine grained, gray when dry	26′		87′		
Clay, fine grained, pinkish when wet	1′		88′		
Clay, light blue	6′		94′		
Clay, brown, hard	6′		100′		
Clay, sandy bluish	7′		107′		
Sandrock, ⅓ argillaceous	6′		113′		
Shale	2′	6″	115′	6″	
Breccia, hard, sand, clay and gray shale cemented	4′	11″	120′	5″	
Shale with layer of coal about 2″ thick and about 7″ from bottom, Verne Coal	27′		147′	5″	at 513 A. T.

TEST HOLE NO. 362.

Elevation above tide is 608′. N. E. ¼, Sec. 12, T. 14 N., R. 3 E.; 550 feet from N. line, 480 feet from W. line. Commenced February 10, 1902; completed February 19, 1902. Amos J. Wampler, driller.

Clay	70′		70′		
Gray shale	38′		108′		
Slate		6″	108′	6″	
Salzburg coal		6″	109′		at 499 A. T.
White shale	7′		116′		
Gray shale	10′		126′		
Coal, Rider	1′		127′		at 481 A. T.
Slate	1′		128′		
White shale	3′		131′		
Gray shale	1′		132′		
Coal, Rider		3″	132′	3″	at 476 A. T.
White shale	1′		133′	3″	

Gray shale	6′	6″	139′	9″	
Slate		3″	140′		
Coal, Upper Rider		3″	140′	3″	at 468 A. T.
Fire clay	8′	9″	149′		
Gray shale	5′		154′		
Slate		3″	154′	3″	
Gray shale	8′	3″	162′	6″	
Slate		6″	163′		
Coal, Lower Verne	2′		165′		at 443 A. T.
Gray shale	16′	6″	181′	6″	
Black shale		6″	182′		
Coal, Middle Rider	1′		183′		at 425 A. T.
Gray shale	6′		189′		
Coal, Saginaw coal	5′		194′		at 414 A. T.
Gray shale	34′		228′		

TEST HOLE NO. 363.

Elevation above tide is 610 feet. N. E. ¼, Sec. 12, T. 14 N., R. 3 E.; 200 feet from E. line, 1,050 feet from N. line. Commenced June 10, 1902; completed June 17, 1902. Amos J. Wampler, driller.

Clay	70′		70′		
Sand	11′		81′		
Gray shale	22′		103′		
Salzburg coal	1′		104′		at 506 A. T.
Gray shale	15′		119′		
Coal, Rider		6″	119′	6″	at 491 A. T.
Gray shale	18′	6″	138′		
Slate	1′		139′		
Coal, Upper Rider	1′		140′		at 470 A. T.
Gray shale	26′		166′		
Black shale	2′		168′		
Gray shale	4′		172′		
Slate	1′		173′		
Coal, Lower Verne		6″	173′	6″	at 437 A. T.
Gray shale	14′	6″	188′		
Coal, Middle Rider	1′		189′		at 421 A. T.
Gray shale	19′		208′		
Coal, Saginaw coal	1′	8″	209′	8″	at 401 A. T.
Gray shale	4′	4″	214′		
Black shale	10′		224′		
Gray shale	5′		229′		

TEST HOLE NO. 364.

Elevation above tide is 600 feet. N. E. ¼, Sec. 12, T. 14 N., R. 3 E.; 700 feet from E. line, 2,000 feet from N. line. Commenced June 28, 1902. Amos J. Wampler, driller.

Clay	88′		88′		
Sand	4′		92′		
Gray shale	18′		110′		
Coal, Upper Rider	1′		111′		at 489 A. T.
Slate	1′		112′		
Gray shale	44′		156′		
Coal	3′	6″	159′	6″	at 441 A. T.
Gray shale		6″	160′		
Sandrock	4′		164′		
Coal, Rider	1′	6″	165′	6″	at 435 A. T.
Gray shale	1′	6″	167′		
Slate		6″	167′	6″	
Coal, Upper and Lower Verne	7′		174′	6″	at 426 A. T.
Gray shale	9′	6″	184′		
Black shale	4′		188′		

Gray shale	7′		195′		
Coal, Middle Rider	1′	6″	196′	6″	404 at A. T.
Gray shale	5′	6″	202′		

TEST HOLE NO. 365.

Elevation above tide is 600 feet. N. E. ¼, Sec. 12, T. 14 N., R. 3 E.; 2,050 feet from N. line, 1,025 feet from E. line. Commenced July 14, 1902; completed July 30, 1902. Amos J. Wampler, driller.

Clay	60′		60′		
Sand	32′		92′		
Salzburg coal	2′		94′		at 506 A. T.
White shale	1′		95′		
Gray shale	21′		116′		
Coal, Upper Rider	2′		118′		at 482 A. T.
Slate	1′	6″	119′	6″	
Gray shale	26′	6″	146′		
Slate		6″	146′	6″	
Coal	4′	2″	150′	8″	at 450 A. T.
Slate		4″	151′		
Gray shale	4′		155′		
Slate		6″	155′	6″	
Coal, Rider	1′		156′	6″	at 444 A. T.
Gray shale		6″	157′		
Slate	1′		158′		
Coal, Upper Verne	1′	11″	159′	11″	at 440 A. T.
Shale		2″	160′	1″	
Coal, Lower Verne	4′	9″	164′	10″	at 436 A. T.
Gray shale	24′	2″	189′		
Coal, Middle Rider	1′		190′		at 410 A. T.
White shale	5′		195′		
Black shale	6′		201′		
Gray shale	12′		213′		

TEST HOLE NO. 366.

Elevation above tide is 610 feet. N. ½, S. ½, N. E. ¼ Sec. 13, T. 14 N., R. 3 E.; 627 feet from N. line, 725 feet from west line. Commenced July 15, 1901, completed July 24, 1901. Amos J. Wampler, driller.

Clay	55′		55′		
Sand	36′		91′		
Clay	4′		95′		
Gray shale	1′		96′		
Salzburg coal		6″	96′	6″	at 514 A. T.
Gray shale	5′		101′	6″	
Coal, Rider		6″	102′		at 508 A. T.
White shale	4′		106′		
Gray shale	3′	6″	109′	6″	
Coal, Rider		6″	110′		at 500 A. T.
White shale	4′		114′		
Gray shale	2′		116′		
White shale	13′		129′		
Gray shale	5′		134′		
Black shale	4′		138′		
Coal, Upper Rider	3′	6″	141′	6″	at 469 A. T.
Slate		6″	142′		
White shale	1′	6″	143′	6″	
Coal	4′	8″	148′	2″	at 462 A. T.
Slate		4″	148′	6″	
White shale	1′	6″	150′		
Black shale	10′		160′		
White shale	4′		164′		
Black shale	2′		166′		

TEST HOLE NO. 367.

Elevation above tide is 612. N. ½, N. ½, S. E. ¼ Sec. 13, T. 14 N., R. 3 E.; 20 feet from N. line, 1,225 feet from E. line. Commenced June 28, 1901; completed July 12, 1901. Amos J. Wampler, driller.

Clay	70′	70′
Sand	82′	152′

TEST HOLE NO. 368.

Elevation above tide is 612 feet. N. ½ of the N. E. ¼, Sec. 13, T. 14 N., R. 3 E.; 437 feet from S. line, 967 feet from W. line. Commenced April 10, 1901, completed May 6, 1901. Amos J. Wampler, driller.

Clay	85′		85′	
Sand	21′		106′	
Gray shale	3′		109′	
Sandrock	3′		112′	
Slate	1′		113′	
White shale	2′		115′	
Sandrock	8′		123′	
Gray shale	20′		143′	
Black shale	16′		159′	
Coal	1′		160′	at 452 A. T.
Gray shale	2′		162′	
White shale	5′		167′	
Gray shale	5′		172′	
Coal, Rider	1′	5″	173′	5″ at 439 A. T.
Gray shale	1′	7″	175′	
White shale	1′		176′	
Gray shale		9″	176′	9″
Slate		3″	177′	
Coal, Rider	1′	7″	178′	7″ at 433 A. T.
Slate		3″	178′	10″
Gray shale	7′	2″	186′	
Coal, Lower Verne	1′	7″	187′	7″ at 425 A. T.
White shale	4′	5″	192′	
Black shale	5′		197′	
White shale	4′		201′	
Gray shale	19′		220′	

TEST HOLE NO. 369.

Elevation above tide is 612 feet. N. W. ¼ Sec. 13, T. 14 N., R. 3 E.; 1,400 feet from W. line, 1,365 feet from N. line. Commenced November 23, 1900; completed December 15, 1900. Amos J. Wampler, driller.

Clay	60′		60′	
Sand	64′		124′	
Sandrock	6′		130′	
Coal	1′	1″	131′	1″ at 481 A. T.
Gray shale	6′	11″	138′	
Coal, Rider	1′		139′	at 473 A. T.
Slate		8″	139′	8″
Coal	3′	6″	143′	2″ at 469 A. T.
Slate		10″	144′	
White shale	2′		146′	
Black shale	6′		152′	
White shale	7′		159′	
Gray shale	9′		168′	
Coal, Lower Verne coal	1′	3″	169′	3″ at 443 A. T.
Slate	2′	9″	172′	
White shale	9′		180′	
Gray shale	25′		205′	

Black shale	32′		237′		
Fire clay	3′		240′		
Black shale	13′		253′		
Gray shale	4′		257′		

TEST HOLE NO. 370.

Elevation above tide is 591 feet. S. ½, N. W. ¼ Sec. 12, T. 14 N., R. 4 E.; 50 feet from E. line, 95 feet from N. line. Commenced February 21, 1902; completed February 27, 1902. Amos J. Wampler, driller.

Clay	56′		56′		
Gravel	2′		58′		
Gray shale	35′		93′		
Salzburg coal	1′		94′		at 497 A. T.
Gray shale	61′		155′		
Slate	2′		157′		
Gray shale	3′		160′		
Coal, Rider		6″	160′	6″	at 431 A. T.
Gray shale	5′		165′	6″	
Slate		6″	166′		
Coal, Lower Verne	3′	7″	169′	7″	at 422 A. T.
Gray shale	4′		173′	7″	
Slate		5″	174′		
Coal, Saginaw coal	3′	10″	177′	10″	at 413 A. T.
Gray shale	7′	2″	185′		
Black shale	4′		189′		
Gray shale	21′		210′		
Sandrock	5′		215′		
Gray shale	2′		217′		
Sandrock	5′		222′		

TEST HOLE NO. 371.

Elevation above tide is 596 feet. N. E. ¼ S. E. ¼, Sec. 12, T. 14 N., R. 4 E.; 252 feet from N. line, 217 feet from W. line. Commenced March 1 1902; completed March 25, 1902. Amos J. Wampler, driller.

Clay	88′		88′		
Sand	28′		116′		
Gray shale	16′		132′		
Coal, Upper Verne	4′	4″	136′	4″	at 460 A. T.
Gray shale	5′		141′	4″	
Slate	1′	8″	143′		
Coal, Rider	2′		145′		at 451 A. T.
Sulphur		8″	145′	8″	
Coal, Lower Verne	5′	5″	151′	1″	at 445 A. T.
Slate		11″	152′		
Gray shale	8′		160′		
Black shale	4′		164′		
Coal, Middle Rider	1′		165′		at 431 A. T.
Gray shale	6′		171′		
Sandrock	4′		175′		
Gray shale	4′		179′		
Sandrock	6′		185′		
Coal, Saginaw coal	1′	10″	186′	10″	at 410 A. T.
White shale	4′	2″	191′		
Black shale	7′		198′		
Coal	2′	3″	200′	3″	at 396 A. T.
Slate		9″	201′		
Gray shale	1′		202′		

TEST HOLE NO. 372.

Elevation above tide is 597 feet. N. E. ¼ S. E. ¼, Sec. 12, T. 14 N., R. 4 E.; 525 feet from E. line, 275 feet from S. line. Commenced March 26, 1902; completed April 8, 1902. Amos J. Wampler, driller.

Clay	60′		60′		
Sand	25′		85′		
Clay	16′		101′		
Sand	5′		106′		
Gray shale	7′		113′		
Sandrock	2′		115′		
Gray shale	4′		119′		
Slate	2′		121′		
Coal	1′	6″	122′	6″	at 475 A. T.
Gray shale	12′	6″	135′		
Coal, Rider	2′		137′		at 460 A. T.
Sulphur		7″	137′	7″	
Coal, Lower Verne	4′	3″	141′	10″	at 456 A. T.
Slate		2″	142′		
Gray shale	22′		164′		
Slate		6″	164′	6″	
Coal, Middle Rider		6″	165′		at 432 A. T.
Gray shale	9′		174′		
Coal, Saginaw coal?	2′	6″	176′	6″	at 421 A. T.
Slate		6″	177′		
Coal	1′		178′		at 419 A. T.
White shale	4′		182′		
Coal		6″	182′	6″	at 415 A. T.
Slate	3′	6″	186′		
Gray shale	1′		187′		
Slate	1′	6″	188′	6″	
Coal		6″	189′		at 408 A. T.
Black shale	19′		208′		
White shale	2′		210′		

TEST HOLE NO. 373.

Elevation above tide is 618 feet. S. ½, S. ½, S. ½, S. W. ¼ Sec. 6, T. 14 N., R. 4 E.; 890 feet from E. line, 157 from S. line. Commenced September 17, 1901; completed October 5, 1901. Amos J. Wampler, driller.

Clay	80′		80′		
Sand	8′		88′		
Gray shale	23′		111′		
Salzburg coal	3′	6″	114′	6″	at 504 A. T.
White shale	3′	6″	118′		
Gray shale	32′		150′		
Slate	1′	6″	151′	6″	
Coal, Upper Rider	1′	7″	153′	1″	at 465 A. T.
White shale	2′	11″	156′		
Gray shale	10′		166′		
Slate		8″	166′	8″	
Coal, Upper Verne	1′	8″	168′	4″	at 450 A. T.
White shale	2′	8″	171′		
Gray shale	16′		187′		
Slate	1′		188′		
Gray shale	8′		196′		
Coal, Lower Verne?	1′	3″	197′	3″	at 421 A. T.
Gray shale	15′		212′	3″	
Coal, Middle Rider		9″	213′		at 405 A. T.
Gray shale	11′		224′		
Coal, Saginaw coal	2′		226′		at 392 A. T.
White shale	2′		228′		
Black shale	4′		232′		
Slate		9″	232′	9″	

Coal, Lower Rider		3″	233′		at 385 A. T.
White shale	3′		236′		
Gray shale	3′	9″	239′	9″	
Slate		3″	240′		
Coal, Lower coal	2′		242′		at 376 A. T.
Gray shale	6′		248′		

TEST HOLE NO. 374.

Elevation above tide is 603 feet. W. ½, W. ½, N. W. ¼ Sec. 7, T. 14 N., R. 4 E.; 48 feet from E. line, 880 feet from S. line. Commenced July 27, 1901; completed August 7, 1901. Amos J. Wampler, driller.

Clay	65′		65′		
Sand	20′		85′		
Gray shale	20′		105′		
Salzburg coal	2′	9″	107′	9″	at 495 A. T.
Slate		3″	108′		
White shale	2′		110′		
Gray shale	8′		118′		
Slate		6″	118′	6″	
White shale	6′		124′	6″	
Gray shale	17′		141′	6″	
Slate		2″	141′	8″	
Coal, Upper Rider	3′	2″	144′	10″	at 458 A. T.
Slate		2″	145′		
Gray shale	8′		153′		
Slate	1′		154′		
White shale	5′		159′		
Slate	1′		160′		
Coal, Upper and Lower Verne	7′	7″	167′	7″	at 436 A. T.
Slate		9″	168′	4″	
Gray shale	19′	5″	187′	9″	
Coal, Middle Rider		3″	188′		at 415 A. T.
Sandrock	4′		192′		

TEST HOLE NO. 375.

Elevation above tide is 610 feet. S. E. ¼, N. W. ¼, Sec. 7, T. 14 N., R. 4 E.; 500 feet from E. line, 700 feet from S. line. Commenced August 9, 1901; completed August 21, 1901. Amos J. Wampler, driller.

Clay	68′		68′		
Sand	48′		116′		
Gray shale	4′		120′		
Coal, Rider		3″	120′	3″	at 490 A. T.
White shale		9″	121′		
Gray shale	11′		132′		
Coal, Rider	1′	3″	133′	3″	at 477 A. T.
White shale	2′	9″	136′		
Slate		3″	136′	3″	
Coal, Upper Rider	1′		137′	3″	at 473 A. T.
Slate		3″	137′	6″	
White shale	1′	6″	139′		
Gray shale	10′		149′		
Coal, Rider	1′		150′		at 460 A. T.
Slate	6′		150′	6″	
White shale	1′		151′	6″	
Slate		6″	152′		
Coal	2′	5″	154′	5″	at 456 A. T.
Slate		7″	155′		
Gray shale	3′		158′		
Coal, Rider		6″	158′	6″	at 452 A. T.
Slate	1′	6″	160′		
Gray shale	16′		176′		
Sandrock	14′		190′		

TEST HOLE NO. 376.

Elevation above tide is 620 feet. S. ½, N. E. ¼ Sec. 7, T. 14 N., R. 4 E.; 1,325 feet from E. line, 50 feet from S. line. Commenced August 23, 1901; completed September 14, 1901. Amos J. Wampler, driller.

Sand	20′		20′	
Clay	55′		75′	
Sand	5′		80′	
Clay	20′		100′	
Sand	52′		152′	
Gray shale	6′		158′	
Slate	1′	6″	159′	6″
Coal, Upper Verne	2′		161′	6″ at 459 A. T.
Slate		6″	162′	
Gray shale	2′	6″	164′	6″
Slate		6″	165′	
Gray shale	14′		179′	

TEST HOLE NO. 377.

Elevation above tide is 604 feet. S. ½, S. ½, S. W. ¼ Sec. 7, T. 14 N., R. 4 E.; 535 feet from E. line, 60 feet from S. line. Commenced April 9, 1902; completed April 18, 1902. Amos J. Wampler, driller.

Clay	60′		60′	
Sand	56′		116′	
Clay	24′		140′	
Gray shale	34′		174′	
Black shale	10′		184′	
Gray shale	40′		224′	
Coal, Lower Rider		6″	224′	6″ at 380 A. T.
White shale	5′	6″	230′	
Gray shale	7′		237′	
Coal, Lower coal	2′	3″	239′	3″ at 365 A. T.
Gray shale		9″	240′	
White shale	4′		244′	
Gray shale	5′		249′	

TEST HOLE NO. 378.

Elevation above tide is 605 feet. S. ½, S. ½, S. W. ¼ Sec. 7, T. 14 N., R. 4 E.; 740 feet from E. line, 275 feet from S. line. Commenced April 19, 1902; completed April 30, 1902. Amos J. Wampler, driller.

Clay	70′		70′	
Sand	58′		128′	
Gray shale	1′		129′	
Coal, Rider	2′	6″	131′	6″ at 474 A. T.
Fire clay		6″	132′	
Gray shale	6′		138′	
Coal, Upper Rider	1′	8″	139′	8″ at 466 A. T.
White shale	6′	4″	146′	
Coal		6′	146′	6″ at 459 A. T.
Gray shale	16′	6″	163′	
Black shale	36′		199′	

TEST HOLE NO. 379.

Elevation above tide is 610 feet. N. ½, S. ½, S. W. ¼ Sec. 7, T. 14 N., R. 4 E.; 610 feet from S. line, 170 feet from W. line. Commenced May 1, 1902; completed May 16, 1902. Amos J. Wampler, driller.

Clay	66′		66′	
Sand	14′		80′	
Clay	3′		83′	

Gray shale	21′		104′		
Sand	2′		106′		
Clay	6′		112′		
Gray shale	11′		123′		
Sandrock	4′		127′		
Gray shale	8′		135′		
Slate		3′	135′	3″	
Coal, Upper Rider	1′	3″	136′	6″	at 474 A. T.
Slate		6″	137′		
Gray shale		6″	137′	6″	
Slate		6″	138′		
White shale	3′		141′		
Gray shale	2′		143′		
Coal, Upper and Lower Verne	7′		150′		at 460 A. T.
Slate	1′		151′		
Gray shale	17′		168′		
Coal	1′	3″	169′	3″	at 441 A. T.
Slate		9″	170′		
Fire clay	7′		177′		
Gray shale	24′		201′		

TEST HOLE NO. 380.

Elevation above tide is 605 feet. N. W. ¼, S. W. ¼, Sec. 7, T. 14 N., R. 4 E.; 480 feet from E. line, 500 feet from S. line. Commenced May 17 1902; completed May 22, 1902. Amos J. Wampler, driller.

Clay	68′		68′		
Gray shale	2′		70′		
Sand	19′		89′		
Gray shale	21′		110′		
Black shale	4′	6″	114′	6″	
Coal rider	1′	6″	116′		at 489 A. T.
Gray shale	13′	6″	129′	6″	
Slate		3″	129′	9″	
Coal, Upper Rider	4′	2″	133′	11″	at 471 A. T.
White shale	4′	1″	138′		
Gray shale	3′		141′		
Black shale	2′		143′		
Coal, Rider		4″	143′	4″	at 462 A. T.
Gray shale	10′	8″	154′		
Coal, Upper Verne	1′		155′		at 450 A. T.
Gray shale	6′		161′		
White shale	4′		165′		
Gray shale	20′		185′		

TEST HOLE NO. 381.

Elevation above tide is 606 feet. N. W. ¼, S. W. ¼ Sec. 7, T. 14 N.,R. 4 E., 200 feet from S. line, 420 feet from W. line. Commenced May 23, 1902; completed May 29, 1902. Amos J. Wampler, driller.

Clay	58′		58′		
Sand	40′		98′		
Gray shale	17′		115′		
Coal, Rider	1′	6″	116′	6″	at 490 A. T.
Slate		6″	117′		
Gray shale	10′	6″	127′	6″	
Slate	1′		128′	6″	
Coal, Rider	1′	6″	130′		at 476 A. T.
Gray shale	2′		132′		
Coal, Upper Rider	2′	9″	134′	9″	at 471 A. T.
Slate		3″	135′		
Gray shale	6′		141′		
Black shale	6′		147′		

Gray shale	11′		158′	
Sandrock	8′		166′	
Gray shale	1′		167′	
Coal, Lower Verne	2′		169′	at 437 A. T.
White shale	1′		170′	
Slate	3′		173′	
Coal, Middle Rider	1′		174′	at 432 A. T.
Gray shale	16′		190′	

TEST HOLE NO. 382.

Elevation above tide is 598 feet. N. ½, S. ½, S. W. ¼ Sec. 7, T. 14 N., R. 4 E.; 350 feet from E. line, 6 feet from N. line. Commenced May 30, 1902; completed June 6, 1902. Amos J. Wampler, driller.

Clay	60′		60′	
Sand	45′		105′	
Slate	9′		114′	
Coal, Rider		6″	114′	6″ at 484 A. T.
Gray shale	7′	6″	122′	
Coal, Rider	1′	4″	123′	4″ at 475 A. T.
Gray shale	3′		126′	4″
Coal, Upper Rider	2′	8″	129′	at 469 A. T.
Gray shale	18′		147′	
Black shale	42′		189′	
Sandrock	3′		192′	
Gray shale	1′		193′	
Black shale	1′		194′	
Fire clay	3′		197′	
Black shale	11′		208′	
Sandrock	3′		211′	

TEST HOLE NO. 383.

Elevation above tide is 600 feet. E. ½, W. ½, N. W. ¼ Sec. 7, T. 14 N., R. 4 E.; 450 feet from W. line, 712 from S. line. Commenced June 19, 1902; completed June 26, 1902. Amos J. Wampler, driller.

Clay	98′		98′	
Coal, Upper Coal	1′	6″	99′	6″ at 501 A. T.
Gray shale	5′	6″	105′	
Coal, Rider		6″	105′	6″ at 495 A. T.
Fire clay	1′	6″	107′	
Gray shale	14′		121′	
Coal, Rider	1′		122′	at 478 A. T.
Gray shale	9′		131′	
Coal, Upper Rider	2′		133′	at 467 A. T.
Gray shale	1′		134′	
Coal, Rider	1′		135′	at 465 A. T.
Sandrock	2′		137′	
Gray shale	6′		143′	
Slate	1′		144′	
Gray shale	8′		152′	
Slate	1′		153′	
Coal, Upper and Lower Verne	7′	1″	160′	1″ at 440 A. T
Gray shale	8′	11″	169′	
Sandrock	8′		177′	

TEST HOLE NO. 384.

Elevation above tide is 605 feet. N. ½, S. ½, S. W. ¼ Sec. 7, T. 14 N., R. 4 E.; 10 feet from S. line, 1,030 feet from E. line. Commenced July 31, 1903, completed August 3, 1903. Amos J. Wampler, driller.

Clay	64′		64′		
Sand	8′		72′		
Clay	18′		90′		
Sandy clay	28′		118′		
Sand	4′		122′		
White shale	3′		125′		
Sandrock	21′		146′		
White shale	4′		150′		
Black shale	3′	8″	153′	8″	
Slate	1′		154′	8″	
White shale	3′	4″	158′		
Slate	3′		161′		
Coal, Lower and Upper Verne	7′	8″	168′	8″	at 437 A. T.
Slate		4″	169′		

TEST HOLE NO. 385.

Elevation above tide is 611 feet. S. ½, S. W. ¼ Sec. 18, T. 14 N., R. 4 E.; 500 feet from W. line, 600 feet from S. line. Commenced March 22, 1901; completed April 6, 1901. Amos J. Wampler, driller.

Clay	25′	25′	
Sand	10′	35′	
Clay	25′	60′	
Sand	80′	140′	
Gray shale	30′	170′	

TEST HOLE NO. 386.

Elevation 613′ A. T. Geo. Campbell. North ½ of N. E. ¼, Sec. 19, T. 14 N., R. 4 E.; 350 feet E. of W. line and 550 feet S. of N. line. Auburn Coal Co., Hole No. 1.

Clay	59′		59′		
Sand and gravel	3′		62′		
Clay	8′		70′		
Gravel	11′		81′		
Sand	9′		90′		
Gravel	7′		97′		
Fire clay	25′		122′		
Salzburg coal		3″	122′	3″	at 491 A. T.
Black slate	9′	9″	132′		
Light slate	5′		137′		
Black slate	3′	6″	140′	6″	
Coal, Upper Verne	5′	6″	146′		at 467 A. T.
Fire clay	1′		147′		
Total	147′				

TEST HOLE NO. 387.

Elevation 607′ A. T. Geo. Campbell. N. ½ of N. E. ¼, Sec. 19, T. 14 N., R. 4 E., 400 feet N. of M. C. R. R. and 1,000 feet W. of E. line.
Auburn Coal Co., Hole No. 2.

Clay	48′		48′	
Sand	10′		58′	
Sandy clay (soft)	8′		66′	
Sand	11′		77′	
Red shale	24′		101′	
Gray slate	15′		116′	
Black slate	6′		122′	
Fire clay	3′		125′	
Black slate	13′		138′	
Coal, Upper Verne	4′	1″	142′	1″ at 465 A. T.
Fire clay	1′	11″	144′	
Total			144′	

TEST HOLE NO. 388.

Elevation 607′ A. T. Geo. Campbell. N. ½ of N. E. ¼, Sec. 19, T. 14 N., R. 4 E., 320 feet W. of E. line and 400 feet N. of S. line.
Auburn Coal Co., Hole No. 3.

Clay		60′		60′	
Sand and gravel		10′		70′	
Black slate		12′		82′	
Sandy clay		16′		98′	
Light shale		2′		100′	
Salzburg coal		2′	8″	102′	8″ at 504 A. T.
Dark shale		21′	4″	124′	
Black slate		13′	10″	137′	10″
Coal	Verne	1′	5″	139′	3″ at 468 A. T.
Sulphur band	Verne		1″	139′	4″
Coal	Verne	1′	1″	140′	5″ at 467 A. T.
Blue slate		1′	7″	142′	
Light shale		33′		175′	
Total				175′	

TEST HOLE NO. 389.

Elevation 607′ A. T. Geo. Campbell. S. ½ of N. E. ¼, Sec. 19, T. 14 N., R. 4 E., 50 feet E. of W. line and 50 feet N. of S. line.
Auburn Coal Co., Hole No. 4.

Clay	60′		60′	
Hardpan	10′		70″	
Sand	42′		112′	
Clay	12′		124′	
Gray slate	34′		138′	
Black slate	1′	6″	159′	6″
Slate and coal		8″	160′	2″
Coal, Lower Verne	3′	1.5″	163′	3.5″ at 444 A. T.
Slate	1′		164′	3.5″
Fire clay	2′	9″	167′	
Gray slate	15′		182′	
Gray shale	6′		188′	
Sandrock	9′		197′	
Total			197′	

TEST HOLE NO. 390.

Elevation 605′ A. T. Geo. Campbell. S. ½ of the N. E. ¼, Sec. 19, T. 14 N., R. 4 E., 590 feet N. of S. line and 607 feet E. of W. line.
Auburn Coal Co., Hole No. 5.

Clay	75′		75′	
Sand	30′		105′	
Gravel	27′		132′	
Coal, Upper Rider		2″	132′	2″ at 473 A. T.
Gray shale	4′	10″	137′	
Black shale	4′		141′	
Gray shale	8′		149′	
Draw slate	1′		150′	
Coal, Upper Verne	4′		154′	at 451 A. T.
Total			154′	

TEST HOLE NO. 391.

Elevation 606′ A. T. Geo. Campbell. S. ½ of N. E. ¼, Sec. 19, T. 14 N., R. 4 E., 500 feet N. of S. line and 835 feet W. of E. line.
Auburn Coal Co., Hole No. 6.

Clay	60′		60′	
Hardpan	20′		80′	
Clay	17′		97′	
Sand and gravel	39′		136″	
Gray slate	2′		138′	
Black slate	6′	6″	144′	6″
Gray slate	2′		146′	6″
Black slate	1″	6″	148′	
Gray slate		7″	148′	7″
Coal, Upper Verne	3′	10″	152′	5″ at 454 A. T.
Slate		3″	152″	8″
White shale	4′	4″	157′	
Shale	1′		158′	
Total			158′	

TEST HOLE NO. 392.

Elevation 609′ A. T. Geo. Campbell. E. ½ of S. E. ¼, Sec. 19, T. 14 N., R. 4 E., S. W. corner.
Auburn Coal Co., Hole No. 7.

Clay	59′		59′	
Hardpan	8′		67′	
Sand	39′		106′	
Clay	2′		108′	
Gravel	4′		112′	
Gray slate	24′		136′	
Coal, Upper Rider	3′		139′	at 470 A. T.
Fire clay	9′	6″	148′	6″
Sandy fire clay	2′		150′	6″
Gray slate	12′	6″	163′	
Sandrock	37′		200′	
Total			200′	

TEST HOLE NO. 393.

Elevation 605′ A. T. Geo. Campbell. E. ½ of S. E. ¼, Sec. 19, T. 14 N., R. 4 E., 950 feet W. of E. line and 10 feet S. of N. line.
Auburn Coal Co., Hole No. 8.

Clay	64′		64′		
Sand	4′		68′		
Hardpan	32′		100′		
Sandy gravel	4′		104′		
Gravel	20′		124′		
Black slate	12′		136′		
Coal, Upper Rider		7.75″	136′	7.75″	at 468 A. T.
Fire clay	6′		142′	7.75″	
Slate	3′	6″	146′	1.75″	
Black slate		6″	146′	7.75″	
Coal, Upper Verne	3′	7″	150′	2.75″	at 455 A. T.
Fire clay	4′	1″	154′	3.75″	
Total			154′	3¾″	

TEST HOLE NO. 394.

Elevation 605′ A. T. Geo. Campbell. S. ½ of N. E. ¼, Sec. 19, T. 14 N., R. 4 E., 1,250 feet W. of E. line and 455 feet S. of N. line.
Auburn Coal Co., Hole No. 9.

Clay	60′		60′		
Hardpan	20′		80′		
Sandy gravel	9′		89′		
Clay	17′		106′		
Gravel	30′		136′		
Gray slate	2′		138′		
Black slate	6′	6″	144′	6″	
Gray slate	2′		146′	6″	
Black slate	1′	6″	148′		
Slate		7″	148′	7″	
Coal, Upper Verne	3′	10″	152′	5″	at 453 A. T.
Black slate		3″	152′	8″	
Fire clay	4′	6″	157′	2″	
Sandy shale	1′		158′	2″	
Total			158′	2″	

TEST HOLE NO. 395.

Elevation 607′ A. T. Geo. Campbell. S. ½ of N. E. ¼, Sec. 19, T. 14 N., R. 4 E., 55 yds. E. of W. line and 8 yds. S. of N. line.
Auburn Coal Co., Hole No. 10.

Yellow clay	12′		12′		
Blue clay	52′		64′		
Hardpan	8′		72′		
Sand, gravel	43′		115′		
Slate	15′		130′		
Sandy shale	9′		139′		
Black slate		7″	139′	7″	
Coal, Upper Verne	3′	6″	143′	1″	at 464 A. T.
Total			143′	1″	

TEST HOLE NO. 396.

Elevation 605′ A. T. Geo. Campbell. E. ½ of S. E. ¼, Sec. 19, T. 14 N., R. 4 E., 120 feet E. of W. line and 200 feet S. of N. line.
Auburn Coal Co., Hole No. 11.

Clay	68′		68′	
Sandy clay	47′		115′	
Sand	10′		125′	
Hardpan	7′		132′	
Sand	3′		135′	
Gray shale	4′		139′	
Dark shale	7′		146′	
Black slate	5′		151′	
C. B. coal, Upper Verne	3′	6″	154′	6″ at 451 A. T.
Black slate		6″	155′	
Fire clay	2′		157′	
Gray shale	3′		160′	
Total			160′	

TEST HOLE NO. 397.

Elevation 608′ A. T. Geo. Campbell. S. ½ of N. E. ¼, Sec. 19, T. 14 N., R. 4 E., 600 feet S. of N. line and 140 feet E. of W. line. (Shaft.)
Auburn Coal Co., Hole No. 12.

Clay	57′		57′	
Hardpan	8′		65′	
Coarse gravel	14′		79′	
Sand, coarse	11′		90′	
Sand, fine	10′		100′	
Gravel	2′	6″	102′	6″
Shale	3′	6″	106′	
Fire clay	2′		108′	
Shale	16′		124′	
Slate	23′		147′	
Coal, Upper Verne	4′	5″	151′	5″ at 457 A. T.
Fire clay		7″	152′	
Total			152′	

TEST HOLE NO. 398.

Elevation 610′ A. T. Hughes farm. S. E. ¼ of N. W. ¼, Sec. 19, T. 14 N., R. 4 E., 100 feet E. of barn.
Auburn Coal Co., Hole No. 13.

Clay	57′		57′	
Sand	4′		61′	
Gravel	69′		130′	
Clay	6′		136′	
Hardpan	1′		137′	
Gravel	2′		139′	
Slate	2′		141′	
Sandrock	7′	6″	148′	6″
Slate	5′	6″	154′	
Coal, Upper Verne	4′	3″	158′	3″ at 452 A. T.
Fire clay		6″	158′	9″
Total			158′	9″

TEST HOLE NO. 399.

Elevation 608′ A. T. Hughes farm. S. E. ¼ of N. W. ¼, Sec. 19, T. 14 N., R. 4 E., N. E. corner S. of M. C. R. R. and W. of Campbell land.
Auburn Coal Co., Hole No. 14.

Clay	63′		63′		
Sand	19′		82′		
Gravel	30′		112′		
Slate	12′		124′		
Sandrock	2′		126′		
Slate	1′	6″	127′	6″	
Sandrock	10′	6″	138′		
Coal, Upper Verne	3′	10.5″	141′	10.5″	at 466 A. T.
Fire clay		6″	142′	4.5″	
Sandy fire clay	4′	6″	146′	10.5″	
Sandrock	11′	1.5″	158′		
Total			158′		

TEST HOLE NO. 400.

Elevation 610′ A. T. Wm. Gaiser farm. N. W. ¼ of S. W. ¼, Sec. 19, T. 14 N., R. 4 E., 500 feet S. of barn.
Auburn Coal Co., Hole No. 15.

Clay	67′		67′		
Sand	2′		69′		
Hardpan	2′	6″	71′	6″	
Sand	8′	6″	80′		
Hardpan	6′		86′		
Sand	4′		90′		
Clay	4′		94′		
Sand	7′		101′		
Slate	8′		109′		
Black slate	2′		111′		
Slate	4′	6″	115′	6″	
Black slate	2′	6″	118′		
Fire clay	7′		125′		
Slate	23′		148′		
Black slate		5″	148′	5″	
Coal, Upper Verne	3′	5″	151′	10″	at 458 A. T.
Total			151′	10″	

TEST HOLE NO. 401.

Elevation 611′ A. T. Wm. Gaiser farm. N. W. ¼ of S. W. ¼, Sec. 19, T. 14 N., R. 4 E., 1,000 feet S. W. of house.
Auburn Coal Co., Hole No. 16.

Clay	60′		60′		
Sand	2′		62′		
Clay	13′		75′		
Gravel	15′		90′		
Sandy gravel	13′		103′		
Sand	9′		112′		
Gravel	6′		118′		
Fire clay	4′	6″	122′	6″	
Slate	2′		124′	6″	
Sandy fire clay	3′	6″	128′		
Fire clay	4′		132′		
Slate	2′		134′		
Sandy fire clay	4′	6″	138′	6″	
Slate	17′	6″	156′		

Black slate		6″	156′	6″	
Coal, Upper Verne	3′	10″	160′	4″	at 451 A. T.
Fire clay	10′	3″	170′	7″	
Total			170′	7″	

TEST HOLE NO. 402.

Elevation 610′ A. T. Anthony Reader farm. In yard near Eight Mile Road. N. W. ¼ of N. W. ¼? Sec. 19, T. 14 N., R. 4 E.
Auburn Coal Co., Hole No. 17.

Clay	56′		56′		
Hardpan	7′		63′		
Gravel	43′		106′		
Sand	21′		127′		
Gravel	10′		137′		
Slate	3′		140′		
Sandrock	9′		149′		
Slate	3′		152′		
Black slate		6″	152′	6″	
Coal, Upper Verne?	4′	5″	156′	11″	at 453 A. T.
Fire clay		6″	157′	5″	
Total			157′	5″	

TEST HOLE NO. 403.

Elevation 610′ feet A. T. Fred Ruffertshofer. S. ½ of S. W. ¼, Sec. 18, T. 14 N., R. 4 E., 600 feet E. of W. line and 500 feet N. of S. line.
Auburn Coal Co., Hole No. 18.

Clay	73′		73′		
Sand and gravel	34′		107′		
Light shale	3′		110′		
Black slate	2′		112′		
Light slate	3′		115′		
Black slate	27′	6″	142′	6″	
Coal, Upper Verne	3′	9″	146′	3″	at 464 A. T.
Total			146′	3″	

TEST HOLE NO. 404.

Elevation 610′ A. T. F. Ruffertshofer. S. ½ of S. E. ¼, Sec. 18, T. 14 N., R. 4 E.
Auburn Coal Co., Hole No. 19.

Clay	55′		55′		
Sand	3′		58′		
Clay	12′		70′		
Gravel	16′		86′		
Clay	3′		89′		
Sand	4′		93′		
Salzburg coal Rider	1′		94′		at 516 A. T.
Light slate	3′		97′		
Fire clay	1′		98′		
Black slate	1′	6″	99′	6″	
Salzburg coal	7′	6″	107′		at 503 A. T.
Fire clay	1′		108′		
Light slate	10′		118′		
Sandrock	3′		121′		
Black slate	26′		147′		

Coal, Upper Verne	4′	6″	151′	6″ at 459 A. T.
Black slate	1′		152′	6″
Fire clay		6″	153′	
Total			153′	

TEST HOLE NO. 405.

Elevation 610′ A. T. F. Ruffertshofer. S. ½ of S. E. ¼, Sec. 18, T. 14 N., R. 4 E.

Auburn Coal Co., Hole No. 20.

Clay	68′		68′	
Hardpan	2′		70′	
Gravel	10′		80′	
Clay	3′		83′	
Sand	3′		86′	
Gravel	6′		92′	
Light slate	8′		100′	
Coal		3″	100′	3″ at 510 A. T.
Fire clay	1′	9″	102′	
Coal (Salzburg Rider)	1′	7″	103′	7″ at 507 A. T.
Fire clay	1′	5″	105′	
Black slate	2′		107′	
Salzburg coal	7′		114′	at 496 A. T.
Fire clay		6″	114′	6″
Light slate	10′	6″	125′	
Black slate	27′		152′	
Coal, Upper Verne	5′	6″	157′	6″ at 453 A. T.
Black slate	1′		158′	6″
Fire clay		6″	159′	
Total			159′	

TEST HOLE NO. 406.

Elevation 608′ A. T. F. Ruffertshofer. W. line of S. ½ of S. E. ¼, Sec. 18, T. 14 N., R. 4 E.

Auburn Coal Co., Hole No. 21.

Clay	86′	86′	
Sand, gravel	44′	130′	
Total		130′	

TEST HOLE NO. 407.

Elevation 607′ A. T. F. Ruffertshofer. N. line of S. ½ of S. E. ¼, Sec. 18, T. 14 N., R. 4 E.

Auburn Coal Co., Hole No. 22.

Clay	85′	85′	
Sand	7′	92′	
Light slate	2′	94′	
Salzburg coal	6′	100′	at 507 A. T.
Light slate	10′	110′	
Black slate	18′	128′	
Light shale	11′	139′	
Sandrock	12′	151′	
Black slate	2′	153′	
Sandrock	24′	177′	
Light slate	1′	178′	
Sandrock	2′	180′	
Total		180′	

TEST HOLE NO. 408.

Elevation 607′ A. T. F. Ruffertshofer. E. line of S. ½ of S. E. ¼, Sec. 18, T. 14 N., R. 4 E.
Auburn Coal Co., Hole No. 23.

Clay	60′		60′	
Gravel	1′		61′	
Hardpan	9′		70′	
Sand	6′		76′	
Gravel	4′		80′	
Sand	6′		86′	
Gravel	6′		92′	
Fire clay	5′		97′	
Light slate	2′		99′	
Black slate	1′		100′	
Fire clay	1′		101′	
Salzburg coal split	1′	7″	102′	7″ at 504 A. T.
Light slate	2′	5″	105′	
Salzburg coal	5′	3″	110′	3″ at 497 A. T.
Light slate	14′	9″	125′	
Black slate	17′		142′	
Coal, Upper Verne	4′	3″	146′	3″ at 461 A. T.
Fire clay		9″	147′	
Total			147′	

TEST HOLE NO. 409.

Elevation 607′ A. T. F. Ruffertshofer. S. ½ of S. E. ¼, Sec. 18, T. 14 N., R. 4 E.
Auburn Coal Co., Hole No. 24.

Clay	55′		55′	
Gravel	9′		64′	
Clay	12′		76′	
Sand	3′		79′	
Clay	6′		85′	
Sand	2′		87′	
Fire clay	1′		88′	
Light slate	9′		97′	
Salzburg coal	4′	7″	101′	7″ at 505 A. T.
Light slate	11′	5″	113′	
Black slate	5′		118′	
Coal, Upper rider	3′	6″	121′	6″ at 486 A. T.
Fire clay	1′	6″	123′	
Sandrock	27′		150′	
Total			150′	

TEST HOLE NO. 410.

Elevation 607′ A. T. F. Ruffertshofer. S. ½ of S. E. ¼, Sec. 18, T. 14 N., R. 4 E.
Auburn Coal Co., Hole No. 25.

Clay	71′		71′
Gravel	14′		85′
Sand	5′		90′
Gravel	19′		109′
Light slate	2′		111′
Sandrock	6′		117′
Light slate	1′		118′
Black slate	2′		120′

Coal, Upper Rider		3″	120′	3″	at 487 A. T.
Fire clay	2′	9″	123′		
Light slate	3′		126′		
Black slate	12′		138′		
Coal, Upper Verne	3′	6″	141′	6″	at 466 A. T.
Fire clay		6″	142′		
Total			142′		

HOLE NO. 411.

Elevation 590′ A. T. In the S. W. ¼ of S. W. ¼, Sec. 30, T. 13 N., R. 6 E. What Cheer Mining Co., Shaft Hole, 1904.

Hard clay	30′		30′		
Soft blue clay	52′		82′		
Hardpan with glacial boulders	7′		89′		
Quicksand		42″	92′	6″	
Hardpan	3′	8″	96′	2″	
Gray shale	2′		98′	2″	
Salzburg coal Rider		10″	99′		at 491 A. T.
Gray shale	8′	2″	107′	2″	
Salzburg coal	1′		108′	2″	at 482 A. T.
Gray shale	7′		115′	2″	
Gray sandrock, plant remains	4′		119′	2″	
Lingula black shale	4′		123′	2″	
Upper Verne coal	1′	6″	124′	8″	at 466 A. T.
Black gray shale	12′	6″	137′	2″	
Coal, Lower Verne Rider	1′	3″	138′	5″	at 452 A. T.
Black shale	10′	9″	149′	2″	
Light sandrock	6′		155′	2″	
Coal	1′	6″	156′	8″	at 433 A. T.
Black shale — Lower Verne	2′	6″	159′	2″	
Coal	2′	8″	161′	10″	at 428 A. T.
Light gray shale	13′		174′	10″	
Blue gray shale	3′		177′	10″	
Sandrock with dark streaks	5′		182′	10″	
Bluish gray shale	3′		185′	10″	
Light clayey micaceous sandrock	2′		187′	10″	
Dark micaceous shale	2′		189′	10″	
Black shale	6′		195′	10″	
Light sandrock, plant remains	1′		196′	10″	
Coal, Saginaw coal	3′	10″	200′	8″	at 390 A. T.
Black slate	6′		206′	8″	

HOLE NO. 412.

United City Coal Co. Shaft in West Bay City. North Union and C., S. & M. R. R. About 600′ A. T.

Clay	78′		78′	
Sand with sandstone boulders	23′		101′	
Sandstone, more bituminous towards bottom	18′		119′	
Lingula black slate	3′		122′	
Coal, Upper Verne	1′		123′	
Gray shale	3′		126′	
Coal, Verne	4′		130′	at 470 A. T.

TEST HOLE NO. 413.

Two hundred ninety-four feet from S. line, 957′ from E. line, S. ½, S. ½, S. E. ¼, Sec. 13, T. 14 N., R. 3 E. The elevation above tide is 613.′

Plastic clay	65′		65′		
Sand	141′		206′		

TEST HOLE NO. 414.

One hundred fifty feet from E. line, 170′ from S. line, E. ½ of the N. E. ¼, Sec. 24, T. 14 N., R. 3 E. The elevation above tide is 610.′

Clay	65′		65′		
Sand	64′		129′		
Gray shale	29′		158′		
Slate		2″	158′	2″	
Coal, Upper Verne		9″	158′	11″	at 451 A. T.
Slate		9″	159′	8″	
Coal, Lower Verne	4′		163′	8″	at 446 A. T.
Gray shale		4″	164′		

TEST HOLE NO. 415.

Two hundred three feet from S. line, 508′ from E. line, W. ½, S. E. ¼, Sec. 17, T. 14 N., R. 3 E. The elevation above tide is 643.′

Clay	65′		65′		
Sandy clay	22′		87′		
White shale	10′		97′		
Gray shale	13′		110′		
Salzburg coal Rider		6″	110′	6″	at 533 A. T.
White shale	5′		115′	6″	
Gray shale	9′	6″	125′		
Black shale	12′	5″	137′	5″	
Salzburg coal	2′	8″	140′	1″	at 503 A. T.
White shale	3′	11″	144′		
Gray shale	63′		207′		
Sandrock	8′		215′		
Gray shale	2′	6″	217′	6″	
Slate		6″	218′		
Coal, Lower Verne	1′	4″	219′	4″	at 424 A. T.
Gray shale	5′	8″	225′		

TEST HOLE NO. 416.

Four hundred feet from W. line, 700′ from N. line, E. ½, S. E. ¼, Sec. 17, T. 14 N., R. 4 E., The elevation above tide is 600.′

Plastic clay	60′		60′		
Sandy clay	19′		79′		
White shale	5′		84′		
Salzburg coal Rider		6″	84′	6″	at 516 A. T.
Gray shale	20′	6″	105′		
Black shale	12′	6″	117′	6″	
Coal, Upper Verne	3′	2″	120′	8″	at 480 A. T.
Gray shale	39′	4″	160′		

TEST HOLE NO. 417.

One thousand three hundred thirty eight feet from N. line, 84′ from E. line, W. ½, N. E. ¼, Sec. 17, T. 14 N., R. 4 E. The elevation above tide is 600.′

Plastic clay	65′		65′	
Sandy clay	25′		90′	
Gray shale	18′		108′	
Black shale	5′		113′	
Coal, Upper Rider	2′		115′	at 485 A. T.
White shale	6′		121′	
Gray shale	55′		176′	

TEST HOLE NO. 418.

Six hundred thirty feet from E. line, 675′ from S. line, N. ½, S. ½, N. E. ¼, Sec. 17, T. 14 N., R. 4 E. The elevation above tide is 590.′

Plastic clay	65′		65′	
Sandy clay	25′		90′	
Gray shale	20′		110′	
Black shale	15′		125′	
Coal, Upper Verne	2′	7″	127′	7″ at 462 A. T.
Slate		5″	128′	
White shale	10′		138′	
Gray shale	42′		180′	

TEST HOLE NO. 419.

One hundred feet from E. line, 480′ from N. line, E. ½, S. W. ¼, Sec. 17, T. 14 N., R. 4 E. The elevation above tide is 600.′

Sand	8′		8′	
Plastic clay	67′		75′	
Sand	39′		114′	
Black shale	12′		126′	
Coal, Upper Verne	2′	4″	128′	4″ at 472 A. T.
White shale	6′	8″	135′	
Gray shale	4′		139′	

TEST HOLE NO. 420.

Twenty-three feet from W. line, 56′ from S. line, W. ½, S. E. ¼, Sec. 17, T. 14 N., R. 4 E. The elevation above tide is 601.′

Clay	60′		60′	
Sand	60′		120′	
Gray shale	9′		129′	
Black shale	11′		140′	
Coal, Upper Verne	2′	8″	142′	8″ at 458 A. T.
White shale	2′	4″	145′	

TEST HOLE NO. 421.

Four hundred feet from E. line, 1,300′ from S. line, W. ½ S. E. ¼, Sec. 17, T. 14 N., R. 4 E. The elevation above tide is 601.′

Plastic clay	65′		65′	
Sandy clay	20′		85′	
White shale	4′		89′	
Gray shale	11′		100′	
Coal, Salzburg coal		3″	100′	3″ at 501 A. T.
White shale	3′	9″	104′	

Slate		6″	104′	6″	
White shale	5′		109′	6″	
Coal, Upper Rider		6″	110′		at 491 A. T.
Gray shale	8′		118′		
Black shale	8′		126′		
Coal, Upper Verne	2′	7″	128′	7″	at 472 A. T.
White shale	4′	5″	133′		

TEST HOLE NO. 422.

Five hundred sixty feet from S. line, 275′ from E. line, W. ½, S. E. ¼, Sec. 17, T. 14 N., R. 4 E. The elevation above tide is 600.′

Clay	60′		60′		
Sand	35′		95′		
Coal, Salzburg coal		6″	95′	6″	at 505 A. T.
White shale	4′	6″	100′		
Black shale	2′		102′		
Gray shale	18′		120′		
Slate	1′		121′		
Gray shale	4′		125′		
Black shale	9′	6″	134′	6″	
Coal, Upper Verne	2′	6″	137′		at 463 A. T.
Gray shale	39′		176′		

TEST HOLE NO. 423.

Three hundred thirty-eight feet from N. line, 700′ from W. line, N. E. ¼, Sec. 18, T. 14 N., R. 4 E. The elevation above tide is 602.′

Plastic clay	62′		62′		
Sand	108′		170′		

TEST HOLE NO. 424

Five hundred ninety feet from S. line, 607′ from W. line, S. ½, N. E. ¼, Sec. 19, T. 14 N., R. 4 E. The elevation above tide is 606.′

Clay	75′		75′		
Sand	30′		105′		
Gray shale	22′		127′		
Coal, Upper Rider		2″	127′	2″	at 479 A. T.
Gray shale	4′	10″	132′		
Black shale	4′		136′		
Gray shale	8′		144′		
Slate	1′		145′		
Coal, Upper Verne	4′		149′		at 457 A. T.
Gray shale	26′		175′		

TEST HOLE NO. 425.

One thousand two hundred fifty feet from E. line, 105′ from N. line, S. E. ¼, of N. E. ¼, Sec. 19, T. 14 N., R. 4 E. The elevation above tide is 605.′

Clay	55′		55′		
Sand	62′		117′		
Gray shale	20′	6″	137′	6″	
Slate		6″	138′		
Coal		11″	138′	11″	at 466 A. T.
Gray shale (Upper Verne)	1′	7″	140′	6″	
Coal		5″	140′	11″	at 464 A. T.
Slate		7″	141′	6″	
Gray shale	28′	6″	170′		

TEST HOLE NO. 426.

One thousand two hundred fifty feet from E. line, 455′ from N. line, S. E. ¼, of N. E. ¼, Sec. 19, T. 14 N., R. 4 E. The elevation above tide is 604.′

Clay	55′		55′		
Sand	57′		112′		
Gray shale	6′		118′		
Slate		6″	118′	6″	
Coal		6″	119′		at 485 A. T.
Gray shale (Upper Rider)	1′		120′		
Coal		6″	120′	6″	at 484 A. T.
Gray shale	17′		137′	6″	
Slate		6″	138′		
Coal	2′	6″	140′	6″	at 464 A. T.
Sulphur (Upper Verne)		10″	141′	4″	
Coal	1′	4″	142′	8″	at 462 A. T.
Gray shale		4″	143′		

TEST HOLE NO. 427.

Thirty feet from E. line, 600′ from N. line, S. W. ¼ S. W. ¼, Sec. 20, T. 14 N., R. 4 E. The elevation above tide is 605.′

Clay	59′		59′		
Gravel	7′		66′		
Sand	72′		138′		
Gray shale	15′		153′		
Coal, Lower Verne	3′		156′		at 449 A. T.
Gray shale	11′		167′		
Sandrock	7′		174′		
Coal, Middle Rider	1′	9″	175′	9″	at 429 A. T.
Gray shale	19′	3″	195′		
Coal		6″	195′	6″	at 410 A. T.
Gray shale (Saginaw coal)	2′	6″	198′		
Coal	1′		199′		at 406 A. T.
Gray shale	2′		201′		
Black shale	19′		220′		

TEST HOLE NO. 428.

Seventy-four feet from W. line, 400 from N. line, W. ½, S. E. ¼, Sec. 20, T. 14 N., R. 4 E. The elevation above tide is 605.′

Clay	60′		60′		
Sand	64′		124′		
Gray shale	11′		135′		
Slate		6″	135′	6″	
Coal, Upper Verne		3″	135′	9″	at 469 A. T.
Black shale	11′	3″	147′		
Coal, Lower Verne	3′	2″	150′	2″	at 455 A. T.
Gray shale		10″	151′		

TEST HOLE NO. 429.

Thirty feet from S. line, 665′ from W. line, S. W. ¼, S. W. ¼, Sec. 20, T. 14 N., R. 4 E. The elevation above tide is 607.′

Clay	63′	63′	
Gravel	10′	73′	
Sand	28′	101′	
Clay	6′	107′	
Sand	35′	142′	
Gray shale	16′	158′	

Coal	Lower Verne	3″	158′	3″ at 449 A. T.
Gray shale		9″	159′	
Coal		2″	159′	2″ at 448 A. T.
Gray shale		26′ 10″	186′	
Sandrock		6′	192′	
Gray shale		2′	194′	

TEST HOLE NO. 430.

Five hundred three feet from N. line, 75′ from W. line, S. W. ¼, S. W. ¼, Sec. 20, T. 14 N., R. 4 E. The elevation above tide is 607.′

Clay	65′	65′	
Sand	15′	80′	
Clay	30′	110′	
Sand	3′	113′	
Gray shale	20′	133′	
Coal, Upper Verne	3′	136′	at 471 A. T.
Gray shale	39′	175′	

TEST HOLE NO. 431.

One hundred ninety-six feet from E. line, 1,382′ from N. line, E. ½, S. W. ¼, Sec. 20, T. 14 N., R. 4 E. The elevation above tide is 603.′

Clay	59′	59′	
Sand	64′	123′	
Black shale	10′	133′	
Gray shale	45′	178′	
Coal, Middle Rider	6″	178′	6″ at 425 A. T.
Gray shale	12′ 6″	191′	
Sandrock	1′	192′	
Gray shale	13′	205′	
Black shale	5′	210′	
Gray shale	2′	212′	
Black shale	6′	218′	
Gray shale	12′	230′	
Slate	1′	231′	
Coal, Lower coal	2″	231′	2″ at 372 A. T.
Gray shale	6′ 10″	238′	

TEST HOLE NO. 432.

Five hundred seventeen feet from W. line, 450′ from N. line, W. ½, N. E. ¼, Sec. 20, T. 14 N., R. 4 E. The elevation above tide is 600.′

Clay	65′	65′	
Sand	43′	108′	
Black shale	17′	125′	
Gray shale	7′	132′	
Black shale	18′	150′	
Coal, Lower Verne	3′ 4″	153′	4″ at 447 A. T.
White shale	8″	154′	

TEST HOLE NO. 433.

Four hundred fifty feet from N. line, 17′ from W. line, W. ½, N. E. ¼, Sec. 20, T. 14 N., R. 4 E. The elevation above tide is 600.′

Clay	60′	60′
Sandy clay	35′	95′
Gray shale	15′	110′
Black shale	10′	120′
Gray shale	20′	140′

Black shale	8′	3″	148′	3″	
Coal, Lower Verne	3′	6″	151′	9″	at 449 A. T.
Slate	1′		152′	9″	
Gray shale	2′	3″	155′		

TEST HOLE NO. 434.

Fifteen feet from W. line, 200′ from S. line, W. ½, N. E. ¼, Sec. 20, T. 14 N., R. 4 E. The elevation above tide is 598.′

Clay	60′		60′		
Sand	58′		118′		
Gray shale	22′		140′		
Coal, Lower Verne	3′		143′		at 455 A. T.
Gray shale	36′		179′		

TEST HOLE NO. 435.

Sixty feet from E. line, 1,240′ from S. line, E. ½, S. E. ¼, Sec. 20, T. 14 N., R. 4 E. The elevation above tide is 602.′

Clay	56′		56′		
Sand	93′		149′		
Gray shale	25′		174′		
Slate		5″	174′	5″	
Coal, Middle Rider	1′	7″	176′		at 426 A. T.
Gray shale	9′		185′		
Black shale	5′		190′		
Gray shale	4′		194′		
Black shale	36′		230′		
Gray shale	36′		266′		

TEST HOLE NO. 436.

Thirteen feet from S. line, 413′ from E. line, N. E. ¼, S. W. ¼, Sec. 21, T. 14 N., R. 4 E. The elevation above tide is 600.′

Clay, plastic	45′		45′		
Sand	50′		95′		
White shale	5′		100′		
Gray shale	9′		109′		
Slate	1′		110′		
White shale	4′		114′		
Gray shale	8′		122′		
Slate	1′		123′		
Coal, Upper Rider	1′	8″	124′	8″	at 475 A. T.
White shale	6′		130′	8″	
Gray shale	40′	4″	171′		
Slate		6″	171′	6″	
Coal, Middle Rider		6″	172′		at 428 A. T.
White shale	3′		175′		

TEST HOLE NO. 437.

Two hundred seventeen feet from S. line, 285′ from W. line, N. E. ¼, S. W. ¼, Sec. 21, T. 14 N., R. 4 E. The elevation above tide is 608.′

Clay	60′		60′		
Sand	50′		110′		
Gray shale	12′		122′		
Coal, Upper Rider		6″	122′	6″	at 486 A. T.
White shale	2′	6″	125′		
Gray shale	29′		154′		
Black shale	3′		157′		

Coal, Lower Verne Rider		8″	157′	8″	at 450 A. T.
White shale	2′		159′	8″	
Gray shale	5′		164′	8″	
Slate		10″	165′	6″	
Coal, Lower Verne		6″	166′		at 442 A. T.
Gray shale	9′		175′		
Black shale	7′		182′		

TEST HOLE NO. 438.

Thirty-two feet from W. line, 820′ from N. line, N. E. ¼, S. E. ¼, Sec. 21, T. 14 N., R. 4 E. The elevation above tide is 610.′

Clay, plastic	55′		55′		
Sandy clay	59′		114′		
Gray shale	55′		169′		
Slate		6″	169′	6″	
Coal, Lower Verne		6″	170′		at 440 A. T.
White shale	1′		171′		
Gray shale	4′		175′		
Slate		6″	175′	6″	
White shale	4′		179′	6″	
Gray shale	13′	6″	193′		

TEST HOLE NO. 439.

Six hundred sixty feet from N. line, 645′ from W. line, N. E. ¼, S. W. ¼, Sec. 21, T. 14 N., R. 4 E. The elevation above tide is 605.′

Clay, plastic	60′		60′		
Sandy clay	40′		100′		
Gray shale	7′		107′		
Coal, Salzburg coal	2′		109′		at 496 A. T.
White shale	10′		119′		
Gray shale	25′		144′		
Slate	1′		145′		
Gray shale	14′	8″	159′	8″	
Slate		4″	160′		
Black shale	2′		162′		
Coal, Lower Verne	2′		164′		at 441 A. T.
Slate	1′		165′		
Gray shale	7′		172′		

TEST HOLE NO. 440.

Three hundred fifty feet from S. line, 250′ from E. line, N. W. ¼, S. E. ¼, Sec. 21, T. 14 N., R. 4 E. The elevation above tide is 600.′

Clay	55′		55′		
Sandy clay	35′		90′		
Gray shale	27′		117′		
Slate		6″	117′	6″	
Coal, Upper Rider	1′		118′	6″	at 482 A. T.
White shale	4′	6″	123′		
Gray shale	4′		127′		
Coal, Upper Verne	1′	6″	128′	6″	at 472 A. T.
White shale	1′	6″	130′		
Gray shale	12′		142′		
Slate		10″	142′	10″	
Black shale	4′		146′	10″	
Gray shale	24′	2″	171′		

TEST HOLE NO. 441.

One hundred eighty-five feet from E. line, 220′ from N. line, S. E. ¼, Sec. 21, T. 14 N., R. 4 E. The elevation above tide is 600.′

Clay	45′		45′		
Sand	58′		103′		
White shale	3′		106′		
Gray shale	51′		157′		
Slate		4″	157′	4″	
Coal, Lower Verne		8″	158′		at 442 A. T.
White shale	5′		163′		
Gray shale	12′		175′		
Slate		3″	175′	3″	
Coal, Middle Rider	1′	4″	176′	7″	at 423 A. T.
White shale	1′	5″	178′		

TEST HOLE NO. 442.

One hundred sixty-one feet from N. line, 831′ from W. line, S. E. ¼, Sec. 21, T. 14 N., R. 4 E. The elevation above tide is 600.′

Clay	55′		55′		
Sand	47′		102′		
Gray shale	25′		127′		
Slate		2″	127′	2″	
Coal, Upper Verne	2′	3″	129′	5″	at 471 A. T.
Slate		1″	129′	6″	
Gray shale	31′	6″	161′		
Black shale	1′	8″	162′	8″	
Coal, Lower Verne		4″	163′		at 437 A. T.
White shale	10′		173′		
Gray shale	2′		175′		

TEST HOLE NO. 443.

Five hundred sixty feet from E. line, 994′ from S. line, S. E. ¼, Sec. 21, T. 14 N., R. 4 E. The elevation above tide is 600.′

Clay	65′		65′		
Sand	34′		99′		
Gray shale	11′		110′		
White shale	10′		120′		
Gray shale	5′		125′		
Coal, Upper Rider	1′	4″	126′	4″	at 474 A. T.
White shale	3′	8″	130′		
Gray shale	42′		172′		

TEST HOLE NO. 444.

Five hundred fifty-five feet from E. line, 646′ from N. line, S. E. ¼, Sec. 21, T. 14 N., R. 4 E. The elevation above tide is 600.′

Plastic clay	45′		45′		
Sandy clay	45′		90′		
Sand	33′		123′		
Gray shale	7′		130′		
White shale	20′		150′		
Gray shale	16′		166′		
Slate		4″	166′	4″	
Coal, Lower Verne		8″	167′		at 433 A. T.
Gray shale	8′		175′		

TEST HOLE NO. 445.

Two hundred thirty-five feet from E. line, 1,255′ from S. line, W. ½, W. ½, S. W. ¼, Sec. 22, T. 14 N., R. 4 E., The elevation above tide is 600.′

Plastic clay	55′		55′		
Sandy clay	24′		79′		
Gray shale	33′		112′		
Black shale	10′		122′		
Coal, Upper Rider	1′		123″		at 477 A. T.
Gray shale	10′		133′		
Slate		4″	133′	4″	
Coal, Upper Verne	3′	5″	136′	9″	at 463 A. T.
Slate		3″	137′		
White shale	7″		144′		
Gray shale	14′		158′		

TEST HOLE NO. 446.

One hundred forty-five feet from S. line, 560′ from W. line, E. ½, N. E. ¼, Sec. 22, T. 14 N., R. 4 E. The elevation above tide is 601.′

Plastic clay	45′		45′		
Sandy clay	70′		115′		
Gray shale	18′		133′		
Black shale	6′		139′		
Coal, Upper Verne		6″	139′	6″	at 461 A. T.
Gray shale	19′		158′	6″	
Slate		3″	158′	9″	
Coal, Lower Verne	1′		159′	9″	at 441 A. T.
Slate		3″	160′		
White shale	13′		173′		

TEST HOLE NO. 447.

Ninety feet from E. line, 1,230′ from S. line, E. ½, N. E. ¼, Sec. 22, T. 14 N., R. 4 E. The elevation above tide is 601.′

Plastic clay	42′		42′		
Sandy clay	53′		95′		
Sand	5′		100′		
Gray shale	21′		121′		
Slate	1′		122′		
Coal, Upper Rider		6″	122′	6″	at 478 A. T.
Gray shale	39′	6″	162′		
Slate		4″	162′	4″	
Coal, Lower Verne	2′	2″	164′	6″	at 436 A. T.
Gray shale	22′	6″	187′		

TEST HOLE NO. 448.

Six hundred forty-nine feet from N. line, 342′ from E. line, E. ½, E. ½, S. W. ¼, Sec. 22, T. 14 N., R. 4 E. The elevation above tide is 600.′

Clay	40′		40′		
Sand	40′		80′		
Clay	20′		100′		
White shale	6′		106′		
Gray shale	9′		115′		
Slate	1′		116′		
Coal	2′		118′		at 482 A. T.
White shale	3′		121′		
Gray shale	45′		166′		
Coal, Lower Verne		3″	166′	3″	at 434 A. T.
White shale	2′	9″	169′		
Gray shale	6′		175′		

TEST HOLE NO. 449.

Three hundred fourteen feet from E. line, 1,259′ from S. line, E. ½, W. ½, S. W. ¼, Sec. 22, T. 14 N., R. 4 E. The elevation is 600′ A. T.

Plastic clay	70′		70′	
Sandy clay	23′		93′	
Gray shale	10′		103′	
Black shale	7′		110′	
Slate		6″	110′	6″
Coal, Gray shale, Coal — Upper Rider	1′	6″	112′	at 488 A. T.
	4′		116′	
		6″	116′	6″ at 484 A. T.
Gray shale	21′		137′	6″
Slate		6″	138′	
Coal, Upper Verne	5′	3″	143′	3″ at 457 A. T.
Slate		9″	144′	
Gray shale	14′		158′	
Coal, Lower Verne	1′	6″	159′	6″ at 440 A. T.
Gray shale	24′	6″	184′	

TEST HOLE NO. 450.

Three hundred fourteen feet from E. line, 259′ from S. line, E. ½, W. ½, S. W. ¼, Sec. 22, T. 14 N., R. 4 E. The elevation above tide is 598.′

Plastic clay	60′		60′	
Sandy clay	13′		73′	
Gray shale	32′		105′	
Black shale	6′		111′	
Coal, Upper Rider		6″	111′	6″ at 487 A. T.
White shale	23′	6″	135′	
Gray shale	25′		160′	
Slate		6″	160′	6″
Coal, Lower Verne		6″	161′	at 437 A. T.
White shale	21′		182′	

TEST HOLE NO. 451.

N. ½, N. W. ¼, Sec. 2, T. 15 N., R. 3 E., 400′ from W. line, 480′ from S. line. The elevation above tide is 632.′

Clay	135′	135′
Sand	27′	162′
Sandrock	10′	172′
Gray shale	2′	174′
Sandrock	2′	176′
Gray shale	3′	179′
Sandrock	22′	201′
Gray shale	9′	210′
Sandrock	86′	296′

TEST HOLE NO. 452.

Two thousand ten feet from E. line, 1,320′ from N. line, N. E. ¼, Sec. 3, T. 15 N., R. 3 E. The elevation above tide is 630.′

Clay	116′	116′
Sand	69′	185′
Sandrock	40′	225′

TEST HOLE NO. 453.

Six hundred feet from S. line, 550' from W. line, N. ½, S. W. ¼, Sec. 23, T. 15 N., R. 3 E. The elevation above tide is 613.'

Sand	8'		8'	
Clay	37'		45'	
Sand	123'		168'	
Gray shale	4'		172'	
Coal	1'		173'	at 440 A. T.
Gray shale	4'		177'	
Coal	1'		178'	at 435 A. T.
Gray shale	12'		190'	
Black shale	10'		200'	
Gray shale	20'		220'	
White shale	5'		225'	
Gray shale	40'		265'	
Slate	1'		266'	
Gray shale	2'		268'	
Black shale	10'		278'	
White shale	5'		283'	
Gray shale	5'		288'	

Verne coals

TEST HOLE NO. 454.

Eighty-five feet from N. line, 595' from E. line, N. W. ¼, N. E. ¼, Sec. 24, T. 16 N., R. 3 E. The elevation above tide is 620.'

Clay	40'		40'	
Sand	40'		80'	
Sandrock	58'		138'	
Gray shale	1'		139'	
Slate		6"	139'	6"
Coal, Upper Rider		6"	140'	at 480 A. T.
Sandrock	2'		142'	
Gray shale	2'		144'	
Sandrock	16'		160'	
Gray shale	5'		165'	
Sandrock	48'		213'	

TEST HOLE NO. 455.

Five hundred fifty-seven feet from E. line, 65' from S. line, N. E. ¼, N. E. ¼, Sec. 24, T. 16 N., R. 3 E. The elevation above tide is 622.'

Clay	50'		50'	
Sand	50'		100'	
Gray shale	25'		125'	
Sandrock	6'		131'	
Gray shale	2'		133'	
Black shale	6'		139'	
Sandrock	14'		153'	
Gray shale	2'		155'	
Slate	1'		156'	
Bone coal, Upper Verne		6"	156'	6" at 465 A. T.
Bituminous coal		6"	157'	
White shale	5'		162'	
Sandrock	13'		175'	
Gray shale	1'		176'	
Sandrock	37'		213'	

TEST HOLE NO. 456

Four hundred forty feet from S. line, 538′ from E. line, S. E. ¼, S. E. ¼, Sec. 24, T. 16 N., R. 3 E. The elevation above tide is 625.′

Clay	65′	65′
Sand	45′	110′
Gray shale	20′	130′
Black shale	2′	132′
White shale	4′	136′
Gray shale	44′	180′
White shale	10′	190′
Gray shale	30′	220′
Sandrock	2′	222′
Gray shale	4′	226′
Sandrock	16′	242′

TEST HOLE NO 457.

Six hundred feet from W. line, 535′ from N. line, S. E. ¼, S. W. ¼, Sec. 32, T. 16 N., R. 3 E. The elevation above tide is 635.′

Clay	65′	65′
Sand	58′	123′
Clay	52′	175′
Sand	5′	180′
Sandrock	36′	216′
Gray shale	4′	220′
Sandrock	10′	230′

TEST HOLE NO 458.

Nine hundred feet from S. line, 200′ from W. line, S. E. ¼, S. E. ¼, Sec. 32, T. 16 N., R. 3 E. The elevation above tide is 633.′

Clay	60′	60′
Sand	84′	144′
Gray shale	6′	150′
Black shale	3′	153′
Gray shale	17′	170′
Sandrock	20′	190′

TEST HOLE NO. 459.

Fifty feet from S. line, 48′ from W. line, N. W. ¼, S. W. ¼, Sec. 33, T. 16 N., R. 3 E. The elevation above tide is 625.′

Clay	55′		55′	
Sand	93′		148′	
White shale	1′		149′	
Slate		6″	149′	6″
Coal, Upper Verne	2′		151′	6″ at 473 A. T.
Slate		6″	152′	
White shale	3′		155′	
Gray shale	4′		159′	
Black shale	5′		164′	
White shale	6′		170′	
Gray shale	8′		178′	
Black shale	6′		184′	
Gray shale	56′		240′	
Sandrock	8′		248′	

TEST HOLE NO. 460.

Two hundred ninety-six feet from N. line, 80′ from W. line, S. E. ¼, S. W. ¼, Sec. 33, T. 16 N., R. 3 E. The elevation above tide is 630.′

Sand	8′		8′	
Clay	47′		55′	
Sand	93′		148′	
Gray shale	1′		149′	
Black shale	2′		151′	
Gray shale	69′		220′	
Sandrock	32′		252′	

TEST HOLE NO. 461.

Two hundred two feet from W. line, 421′ from S. line, S. W. ¼, N. W. ¼, Sec. 30, T. 16 N., R. 4 E. The elevation above tide is 620.′

Clay	70′		70′	
Sand	10′		80′	
Clay	20′		100′	
Sand	6′		106′	
White shale	2′		108′	
Slate	1′		109′	
Gray shale	6′		115′	
Slate	1′		116′	
Salzburg coal	2′	6″	118′	6″ at 502 A. T.
Slate		6″	119′	
Gray shale	6′		125′	
Black shale	10′		135′	
Brown shale	5′		140′	
Gray shale	62′		202′	
Sandrock	27′		229′	

TEST HOLE NO. 462.

One hundred forty-four feet from N. line, 642′ from W. line, N. W. ¼, N. W. ¼, Sec. 30, T. 16 N., R. 4 E. The elevation above tide is 617.′

Sandy clay	70′		70′	
Gravel	5′		75′	
Plastic clay	20′		95′	
Sand	15′		110′	
Slate	5′		115′	
Gray shale	55′		170′	
Slate	2′		172′	
Gray shale	4′		176′	
Coal, Lower Verne		4″	176′	4″ at 441 A. T.
Black shale		8″	177′	
Gray shale	50′		227′	
Sandrock	21′		248′	

CHAPTER IV.

FORMATION OF THE SOILS AND SUB-SOILS. THE QUATERNARY.

1. *Thickness of the Drift.*

At no place within the limits of Bay county does bed rock reach the surface. The depth of the drift formation varies from 30 feet in the northern part of Fraser township to 220 feet in the vicinity of Auburn, and 227 feet in the northwest quarter of section 21, Beaver. This great accumulation of drift is doubtless exceeded in depth farther west, inasmuch as a test hole for coal put down by J. Coryell in section 24, T. 15 N., R. 2 E., and just over the line in Midland county, shows 249 feet of unconsolidated material above the bed rock. Another drilled well near the north quarter post of section 18, T. 14 N., R. 3 E., has 217 feet of drift and no rock. In the northwestern part of Bay county, the elevation of the bed rock increases, but the greater development of the drift leaves the minimum amount of drift formation as noted above in Fraser township. Thus we have 115 feet of drift in a well recently put down by Wm. Hinman at Bently, at 737 feet A. T., which makes the bed rock at 622 feet or approximately 60 feet higher than the highest rock elevation in Fraser township.

Additional details showing the thickness of the drift in the northern part of the county are rather wanting. The records of three test holes for coal put down on the property of J. Mansfield in the southwest quarter of section 11, Mt. Forest township, show from 90 to 92 feet of drift. At Mt. Forest station bed rock is said to have been struck at 90 feet. In the southern part of the township, two test holes for coal in sections 33 and 34, show respectively 107 and 121 feet of drift. To the eastward in Pinconning township, the amount of drift varies from 35 to 40 feet as in the eastern part of the township, to 73 feet in section 19 adjacent to Mt. Forest. A comparison shows that the amount of drift increases westward from the bay shore, to the Gladwin county line. At Estey there is 137 feet of drift, or considerably more than has thus far been obtained in either Mt. Forest or Pinconning townships.

We have already had occasion to notice the subordinate bed rock divide, having a lobate structure, which opens out to the northward from Michie P. O., in the northern part of Fraser township. In this area there is only 28 feet of drift in the southeast quarter of section 2; in the N. W. ¼ of the S. E. ¼ of section 4, the drift amounts to 30 feet, increasing to 45 feet in the N. W. ¼ of the same section, and to 72 feet near the south quarter post of section 4. A drift filled channel apparently heads in near this last location, meandering southwest and across the southeastern portion of Garfield township. In this old drainage channel there are two wells which reach the rock at a depth of 90 feet in sections 16 and 19 of Fraser. Northwest and southeast from here the drift varies from 70 to 80 feet in depth, at slightly different elevations above the bay. In the N. E. ¼ of section 24, Garfield, we have from 80 to 100 feet of drift, the amount increasing to the southeast as we approach this buried channel, designated the Beaver washout in our

chapter on coal. In these two records the upper half is clay, probably of Wisconsin age. In the southeast part of the same section we have 65 feet of clay and 45 feet of sand down to a depth of 110 feet. Across the township line from here, in the N. W. ¼ of section 30, Fraser, there is from 106 to 110 feet of drift, the upper 70 feet being of clay, the balance of sand, gravel and clay. The general tendency is for the drift to increase in depth toward the southwestern part of Fraser, north of that corner of the township. Similarly the depth of the drift in Garfield township increases to the south, and more especially in the southeastern portion adjacent to the area in Fraser township just described. Near the southwest corner of section 4, Garfield, Mr. F. J. Tromble went through 127 feet of drift, which is approximately the same as was found in the south central part of Mt. Forest, less than two miles north. This rapid increase in the elevation of the bed rock towards Mt. Forest Station northward, indicates that the depth of the drift increases toward the south in Garfield, forming a part of the gradual increase in morainal accumulations toward the southern and southwestern portion of the county.

In conformity to this we have in S. W. ¼ of section 32 of Garfield, T. 16 N., R. 3 E., 180 feet of drift, the upper 65 feet being clay, probably of Wisconsin age, the earlier beds of sand and clay being at least pre-Wisconsin in part. In the S. W. ¼ of section 33, one mile east, there is 148 feet of drift, the top eight feet being sand underlain by 47 feet of clay; the balance is sand. Near the south quarter post of section 26, Garfield, there is about 135 feet of drift.

The Beaver washout which extends south and west, through the central and southwestern part of Beaver township, has a great accumulation of drift material where the bed rock has been washed away. Following down the main area of this buried valley, as near as our data can locate the same, it is noticeable that the amount of drift constantly and rather rapidly increases southward. In the N. W. ¼ of section 2, Beaver, we have 135 feet of clay and 27 feet of sand; in the N. E. ¼ of section 3 there is 116 feet of clay and 69 feet of sand; both drill holes entered the rock. This is 115 feet more drift than where the channel heads in Fraser township. At Kimel's store, near the N. W. corner of section 21, Beaver, there is 227 feet of drift; in the northwest quarter of section 33, 225 feet. Northwest of this area the depth of the drift, as far as we can ascertain from certain records in Midland county, and from a drill hole for coal in the N. E. ¼ of section 7, Beaver, decreases to 119 feet in the latter place. East of the Beaver washout, and in the eastern part of the same township, there is near the west quarter post of section 23 eight feet of lacustrine sand deposits at the surface, underlain by 37 feet of clay and 123 feet of sand, rock being struck at 168 feet. This is 59 feet less than two miles to the westward. Comparing this record with the one in the N. W. ¼ of section 2, about three miles to the north, we have the amounts of clay and sand almost reversed. This may be due to the sand being pushed forward by the advance of the Wisconsin glacier. Anyway these two records show the great variability of the drift through this region. Near the west quarter post of section 24, at Lochne P. O. there is said to be 136 feet of drift or 32 feet less than about one mile to the westward. South from here in the east part of section 34, two well records show from 70 to 85 feet of drift or 32 feet less than about one mile to the westward. At Soper's mill near the southwest corner of section 2, it is said to be 150 feet to the rock.

In the continuation of this heavy drift filled channel into Midland county, there is 249 feet of drift in section 24, T. 15 N., R. 2 E.

Extending east from Beaver the accumulation of drift material in Kawkawlin township, is comparable to the section in the last northern tier of townships, in that the amount of drift material constantly decreases in depth toward the east, which is also true in a general way with Fraser and Garfield. The greater amount of drift deposited in Beaver township, is in line with the more massive deposits in the southwestern portion of this township, and consequently the section is more strongly accentuated toward the west than in the next tier of townships to the north.

An examination of rather numerous well records collected by W. T. Shaw throughout Kawkawlin township, and the records of 19 test holes for coal put down in the eastern portion of the township adjacent to the bay, indicates that the amount of drift varies from 80 to 90 feet in the western tier of sections, to from 58 to 74 feet in the area adjacent to the bay. As will be seen by referring to the rock contour map, there are apparently no washouts in the bed rock underlying Kawkawlin. The area adjacent to the bay, is underlain in part by massive beds of sandstone, which may account for the lesser amount of drift deposited. This is quite noticeable in the southern part of the state, where the Marshall sandstone has relatively a small amount of superincumbent drift materials, when compared to the adjacent Coldwater shales to the south and east.

In T. 13 N., R's. 4 and 5 E., and T. 14 N., R's. 3, 4 and 5 E., corresponding with the civil divisions of Frankenlust, Williams, Monitor, the Bay Cities, and portions of Bangor, Hampton and Portsmouth townships, the distribution of the drift formation is very irregular. I will first attempt to give the main features of this area, adding such details as may seem necessary to give a correct idea of the drift distribution in this area. In Williams, T. 14 N., R. 3 E., the Beaver washout in its higher portion includes the northwestern part of this township. Westward in Midland county, this washout unites with the Auburn washout, or old buried valley, which runs under that village, and probably south of the Midland stone road, heading in north of Colfax P. O., near the line of sections 21 and 28, T. 14 N., R. 4 E. This Auburn washout received from the north, a tributary valley which runs northeast in the northwestern part of Monitor. West of this tributary valley and extending down into section 17, Williams, the bed rock rises having a much less amount of drift accumulation. Also the drift is less in the southeastern part of Williams, extending into section 27, T. 14 N., R. 4 E., northeast of Colfax P. O.

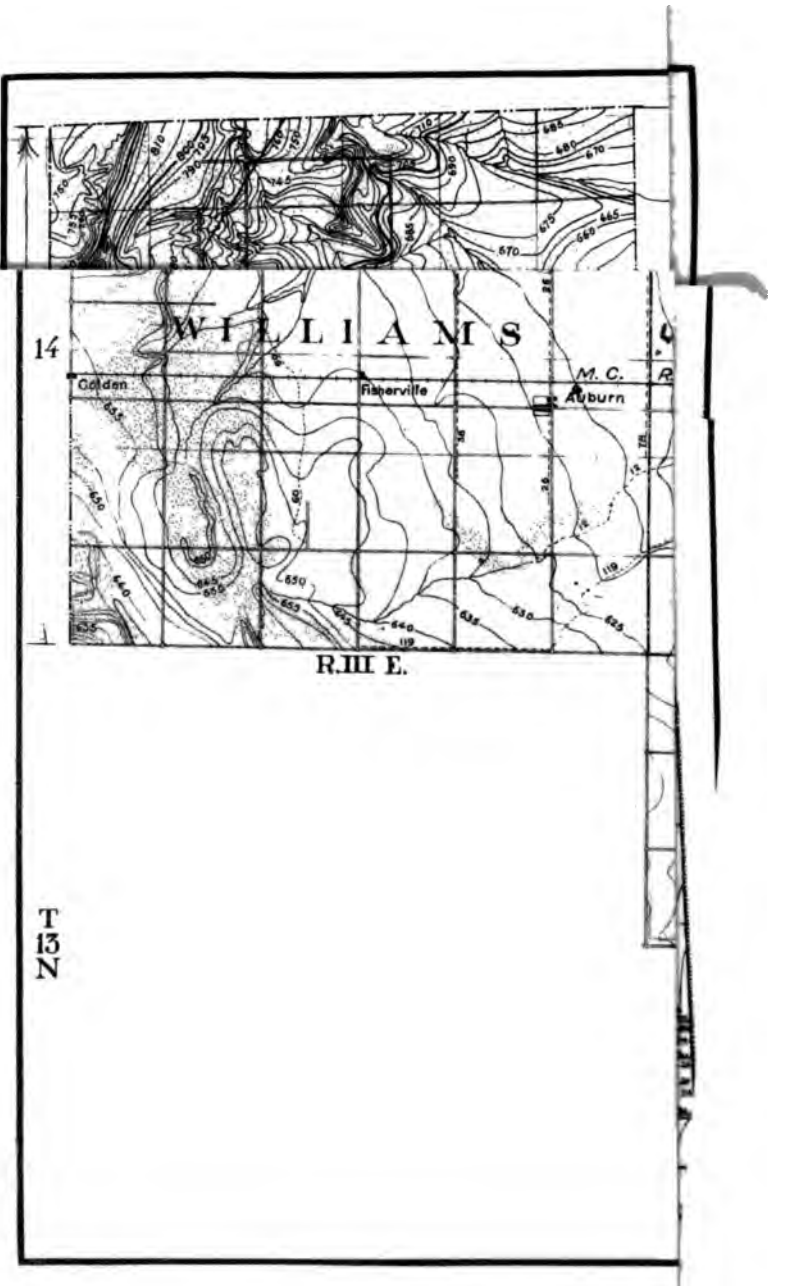
The Amelith washout extends from near the mouth of the Saginaw river, west and south through the central part of Bangor township, the eastern part of Monitor township, and thence through the northern part of Frankenlust township, having a much greater amount of drift than in narrow adjacent areas in its lower reaches, the amount of drift increasing about half. In its upper reaches, however, the drift is more constant and evenly distributed beyond its limits. This Amelith washout is separated by a bed rock divide from the Souwestconning washout underlying the Middle ground, and running mainly southwest through the eastern part of Frankenlust township. West of the northern part of this last area, in section 19, T. 14 N., R. 5 E., there is a comparatively small amount of drift east of the Amelith washout in Monitor township. The remaining eastern portion of Bay county has a comparatively even amount of drift accumulation.

I will now proceed to give some idea of the thickness of the drift in these areas, taking them up in the same order.

The border of the Beaver washout in the northwestern part of Williams township is based altogether on comparative data. In the N. W. ¼ of section 33, Beaver, there is over 225 feet of drift. In the S. E. ¼ of section 17, Williams, we have 65 feet of clay and 22 feet of sandy clay above the bed rock, showing a decrease of over 138 feet in the amount of drift within four miles.

In the Auburn washout it is 220 feet to rock at the village of Auburn. In the S. ½ of the S. E. ¼ of section 13, Williams, we have 65 feet of clay and over 141 feet of sand, somewhat above the point of juncture of the tributary valley, mentioned as coming in from the northwestern part of Monitor township. East of Auburn this buried valley swings slightly to the south of the Midland stone road in the west half of Monitor township. In the southeast quarter of section 21 there is 148 feet of drift, the upper 74 feet being clay and hardpan, the balance sand and gravel. Within a few rods to the north, in the same quarter section, we have 90 feet of clay above the rock. Near the east line of the same quarter section there is 65 feet of clay and 34 feet of sand. I believe that this washout heads in near here. Thence east near the divide between this washout and the Amelith washout which runs south near the line of sections 23 and 24, we have on this divide in the S. W. ¼ of section 22 only 73 feet of clay drift increasing to 95 feet of clay and 5 feet of sand in the N. E. ¼ of section 22 and 115 feet of drift in the S. E. ¼ of the same quarter section.

We will now take up the area in the northern part of Monitor township lying north of the Auburn washout, west and north of the Amelith washout, and east and north of the tributary valley to the Auburn washout running through the northwest part of Monitor. In the south half of section 19 we have from 114 to 125 feet of drift, the upper drift series being from 67 to 90 feet thick. In the north half of the same section the drift decreases in depth to 70 and 77 feet, the amount of clay drift being 60 and 48 feet respectively. Thence north in the south half of section 18, and south of the tributary Auburn washout, the drift varies in depth in the south half of the S. W. ¼, from 107 to 140 feet, within 100 feet going northwest. About 80 rods west of here there is over 206 feet of drift, the upper 65 feet being clay, about the same as in the two holes to the east. In the S. E. ¼ of section 18, there is from 92 to 109 feet of drift, the upper clay formation varying from 70 to 85 feet. The tributary valley area north from here will come in for remarks in the next paragraph. In the tier of sections 20 and 17, lying east of the last two discussed, we will begin at the south and work north as before. In the south half of section 20 the drift increases in depth toward the north and south quarter line. We thus have near the south quarter post of section 20, over 143 feet of drift, the upper 94 feet being the upper clay formation. Going west, in the S. W. ¼ of this section, the drift decreases in depth from 138 feet to 113 feet near the west line of the section, with from 59 to 65 feet of clay drift on top. In the S. E. ¼ of the S. E. ¼ of Sec. 20, there is 149 feet of drift on the northern border of the Amelith washout, the lower 93 feet being sand. In the N. E. ¼ of the same quarter section we have only 94 feet of drift. In the north half of section 20, we again find the drift increasing in depth toward the south central part, or the center of the section, where it is 131 feet to rock, the upper 60 feet being clay. In the S. W. ¼ of the N. W. ¼ there is 100 feet of drift, the lower 50 feet being sand and gravel. In the N. E. ¼ the drift varies from 95 to 118 feet,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occupying the greater portion of the northern half of Williams township, we have some data to offer. In section 13, Williams, and on the north side of the Auburn washout there is 124 feet of drift, the upper 60 feet being clay. Going northeast along the rise of the bed rock, into the south half of section 7, Monitor, we have from 68 to 83 feet of drift, the greater part being clay. Adjacent to this, in the N. E. ¼ of section 12, Williams, we have from 70 to 92 feet of drift, the upper clay drift being from 60 to 92 feet deep. On the bed rock divide running northeast from near the southeast quarter of section 17, Williams, we have in this last place 87 feet of clay drift down to the rock. Thence northeast, in the S. E. ¼ of the S. E. ¼ of section 9, there is from 85 to 90 feet of drift. Near North Williams P. O., in the N. W. ¼ of section 11, Chas. Coryell went through 110 feet of drift. There is 93 feet of drift near the northeast corner of section 11, 124 feet one mile and a half south, and 220 feet at Auburn, which serves to give an idea of the profile across the north side of the washout. In the north tier of sections forming Williams township, we have in sections 2 and 3, from 75 to 90 feet of drift and apparently no rock. Near the southeast corner of section 4 at the Hardy place, there is 71 feet of clay and hardpan, 20 feet of fine sand, then 2.5 feet of gravel probably resting on the rock. In the northwestern part of Williams we only have one well into the rock. There is 198 feet of drift near the northwest corner of section 19.

We will now take up the region in the southeast part of Williams, the southwest part of Monitor, and that portion of Frankenlust north and west of the Amelith washout. This area is bounded on the east by the Amelith washout and by the Auburn washout on the north, in Monitor township. In the S. ½ of the S. E. ¼ of section 28, Williams, there is said to be 187 feet of drift. To the east, in sections 25 and 26, we have from 122 to 125 feet of drift and no rock. In the northeast quarter of section 34, Williams, we have a drilled well 143 feet deep, and 80 feet of clay on top. Thence east in section 30 of Monitor, we have on the farm of John Zill 57 feet of clay, 60 feet of sand, then gravel probably underlain by rock. In the S. E. ¼ of section 31, Monitor, there is over 130 feet of drift. South from here in Frankenlust I believe that the drift increases in depth. In the next tier of sections to the east, making sections 29 and 32 of Monitor, and 5 of Frankenlust, we have the records of a few drill holes for coal. In the S. E. ¼ of section 29 there is 121 feet of drift, the upper 105 feet being clay. Near the S. E. ¼ of the same section, going south from the Auburn washout, we have 115 feet of drift. Near the north line of section 5, Frankenlust, there is from 115 to 124 feet of drift, increasing to 127 feet in the center of the N. E. ¼ of the same section. Thence east again in sections 28 and 33 of Monitor, and 4 of Frankenlust, located west of the Amelith washout, we have the least accumulation of drift material in this part of Monitor and Frankenlust townships. This is just south of the area previously described in sections 16 and 21 of Monitor. In the south half of section 28 the drift decreases in depth near the southeast corner to 81 feet with only 74 feet in the adjacent quarter section to the east. West from here we have about 100 feet of drift. South from here in section 33, we have from 84 to 116 feet of drift, the greatest amount being toward the southwest. In section 4 of Frankenlust we have 90 feet of drift in the center of the section, and 111 feet near the shaft hole of Bay No. 2 mine in the S. E. ¼. Near the southwest corner of section 3, in the Amelith washout, there is over 190 feet of drift, which brings us to this subject.

The existence of this Amelith washout is somewhat insufficiently based

on rather meager data, largely of a comparative nature. To the north and west of the test hole in section 3, S. W. ¼, the west and north sides of this channel respectively show from 131 to 147 feet of drift, which as we have seen, decreases to 104 feet in the center of section 4, Frankenlust. The records adjacent to the shaft of the Hecla Portland Cement & Coal Co., in section 2 of Frankenlust, also show a considerable falling off in this direction, there being from 68 feet of drift in the eastern part of the section to 123 feet in the northwest quarter. The same may also be said to be true in the territory contiguous to the Amelith shaft in section 15. Near the northwest corner of that section there is 168 feet of drift, which decreases to 132 feet within 40 rods to the southeast. Throughout the rest of this section there is from 106 to 147 feet of drift material. In the southwest quarter of section 17, Frankenlust, a well record gives a total depth of 137 feet to the rock. North from here in the north half of section 5 there is from 115 to 124 feet of drift. I have imagined these last two locations as being on the north and south sides of the Amelith washout. In the N. E. ¼ of section 35, Monitor, we have 175 feet of drift in the northerly continuation of this buried channel. In the N. W. ¼ of the N. W. ¼ of section 26, adjoining on the north, there is only 80 feet of drift on the west side of the washout. Going east and west across this washout, on the quarter line of sections 23 and 24, we have in the N. E. ¼ of the S. W. ¼ of section 23, rock at 107 feet; in the N. W. ¼ of the S. W. ¼ of section 24, from 88 to 130 feet of drift and 85 feet in the N. W. ¼ of the S. E. ¼ of 24. In section 12 of Monitor the drift increases from 58 to 106 feet in thickness going southeast toward this washout area. In the N. E. ¼ of the S. E. ¼ of section 7, Bangor, we have 175 feet of drift north of the bottom of this washout. In the north half of section 4, the drift increases from a depth of 72 feet, as near the shaft of Wolverine mine No. 1 and the Wenona beach mine, to a depth of over 178 feet in the washout south of the former location, and in the same section. About 80 rods south of here we have 90 feet of drift near the S. W. ¼ post of the same section. This washout probably heads over in Huron county passing near Unionville. The course is very narrow in places, with an abrupt descent which possibly accounts for the limited amount of information that I have been able to get concerning it.

On the bed rock divide east of the Amelith, and west of the Souwestconing washouts, we have in section 15 of Frankenlust, from 106 to 147 feet of drift with a well marked interglacial bed at 110 feet. The upper drift here has an average thickness of 114 feet being as usual underlain by beds of sand and gravel. Thence northeast along the bed rock divide, and in section 11, there is from 96 to 108 feet of drift in two drill holes there. In the adjoining section 12 to the east, we have in the north half, very nearly 80 feet of drift, increasing to over 162 feet where we get down into the Souwestconing washout at the south quarter post of this section. Thence north again in the east half of section 1, and the N. W. ¼ of the S. W. ¼ of section 6, just east, we get quite generally from 79 to 83 feet of drift in rather numerous records. In the property leased by the Hecla company in section 2 of Frankenlust, we have 24 drill records which show from 68 feet of drift near the south and east quarter posts of the section, to 120 and 123 feet near the west 80-rod line. The upper clay drift is from 64 to 120 feet thick. Thence northeast again along this old bed rock divide into section 36 of Monitor, we have the drift increasing in depth from 68 to 109 feet toward the north. In section 25 adjoining on the north, there is from 75 to 115 feet of drift from east to west as we get into the Amelith washout, but alto-

gether rather irregularly distributed. East from here in sections 30 and 29 we get from 76 to 97 feet of drift. In West Bay City and section 19 adjoining on the west, the bed rock increases in elevation northward, having the least amount of drift formation in the north half of section 19 and the northwest portion of 20. In this area we have from 80 to 93 feet of drift on this old divide, increasing to 100 feet within a short distance. The drift in West Bay City is generally from 80 to 90 feet thick. South of the Amelith washout and the Kawkawlin river, and north of West Bay City, we have in 10 drill holes, from 78 to 90 feet of drift in Bangor township.

Data concerning the Souwestconing washout is rather wanting. In the southeast quarter of section 14, on the Neumeyer places, the drift increases from 82 to 130 feet in depth. Near the south quarter post of section 12 we have over 162 feet of drift, in the N. W. ¼ of 13, 109 feet, near the center of section 12, 80 feet. As we have seen there is 80 feet of drift around the Valley mine in section 1, T. 13 N., R. 4 E. From here the drift is 105 feet thick at the North American Chemical Company's deep well at South Bay City.

East of the Saginaw river and in that part of Portsmouth township included in the eastern half of T. 13 N., R. 5 E., there is from 80 to 125 feet of drift, rather irregularly distributed, but showing a tendency to increase toward the south. I did not obtain any records in the lowlands adjacent to the Saginaw river, with the exception of the record in section 5, at the deep well of the North American Chemical Co. at South Bay City. In T. 14 N., R. 5 E., either in or adjacent to the east boundary line of Bay City, we have 10 records from Goff Paul, which show from 88 to 105 feet of drift increasing in depth south and west, the same as in the adjacent township to the south where we have at least 125 feet of drift accumulation. This decrease continues to the northward, until, just east of the mouth of the Saginaw river, we haye from 75 to 82 feet of drift on the Penniman property. In T's. 13 and 14 N., R. 6 E., included for the most part in the civil divisions of Merritt and Hampton townships, there is from 79 to 80 feet of drift, to as much as 108 feet in the west central part of Merritt. The greater part of our records indicate from 80 to 90 feet of drift.

An average of 460 drill holes for coal would make the thickness of the drift just 100 feet. These drill holes are all located in the lower third of the county, with the exception of 40 holes. Very nearly 365 records are in three government townships. A more even distribution of these records would doubtless give a truer idea of the average thickness. Additional information based on 126 well records scattered promiscuously over the county, make the average depth of the drift 86 feet. A combined average of our drill and well records would make the drift 97 feet thick in this county. In this estimate I have included the overlying lake sands deposited during the stages of thc glacial retreat. For the average thickness of the different subdivisions of the drift, the reader is referred to the following section.

2. *Subdivisions of the Drift.*

In several drill and shaft holes for coal put down in the southern part of the county, beds of vegetation were passed through, which have been taken as either demarking the deposits of the Wisconsin epoch of glaciation from the pre-Wisconsin, or as forming subordinate divisions of the Wisconsin drift sheet. There are at least two beds of plant deposits contained in the Bay county drift, the upper bed probably subdividing the Wisconsin drift

into two portions; the lower bed separating the Wisconsin from the pre-Wisconsin drift. The upper drift, mentioned in the preceding section is probably of Wisconsin age, and is composed of clay and hardpan, underlain by beds of sand, gravel and hardpan forming the lower or pre-Wisconsin drift.

Beds of vegetation were obtained by Leonard Zill in the center of section 19, Bangor township, at a depth of 80 feet; for 37 feet below the formation is said to be a boulder clay. As will be seen farther on, the depth of the deposit conforms in a general way with the main physical division of the drift formation in other sections. In the S. E. ¼ of section 28, T. 14 N., R. 4 E., near the old Monitor shalt, Goff Paul went through a bed of sand containing gas which has probably resulted from the decay of plant remains, at a depth of 80 feet. This was overlain by beds of clay and hardpan, and underlain by rapidly alternating deposits of sand, gravel and hardpan. The plant deposits here conform to the physical division into two principal parts, into which the drift deposits of Bay county have been divided. At the Hecla shaft in section 2 of Frankenlust, plant remains were found in beds of sand at a depth of 83 feet. This was here overlain by beds of clay containing boulders toward the bottom, and underlain by bed rock. There is just a possibility that this represents a preglacial soil deposit, but on the other hand this section is quite comparable to those already mentioned as being found at about this depth. I am inclined to believe that this deposit is interglacial, but with the underlying beds of drift not represented. The greatest development of the lower drift formation is found in the washouts where the earlier deposits were protected during the subsequent readvance of the ice.

The first specimens of interglacial wood were presented the Survey by Mr. John Werner, Superintendent of the Pittsburg Coal Company's shaft, situated near the center of section 15, T. 13 N., R. 4 E., and southeast of Amelith P. O. They were found at a depth of 110 feet. Not having a section of the shaft record I am unable to correlate these specimens exactly with any variation in the structure of the drift, but the average thickness of the upper or Wisconsin (?) deposits in the same section is 114 feet. The specimens present the aspect of being badly crushed by ice pressure. Prof. T. C. Chamberlin is of the opinion that these beds of clay and hardpan forming our upper drift, and underlaid with the bed of plant material from the above described localities, is of Wisconsin age.

The Wisconsin drift varies in our different drill records from 30 feet in thickness as in section 30, T. 15 N., R. 5 E., to 148 feet in section 15, T. 13 N., R. 4 E. An average of our maxima and our minima from 12 different government townships varies from 103 to 50 feet in depth. In 443 drill holes for coal the average thickness for the Wisconsin drift is 82 feet. It will be observed that this conforms quite closely with the depth of the bed of organic materials just described, with the exception of the Amelith plant deposit. This also indicates that the physical characters which I have used in working up the data agrees with the facts obtained from this plant bed. This bed will be designated the Lower Monitor soil horizon from its occurrence in the abandoned shaft hole of the old Monitor mine situated in the southeast ¼ of section 28 of Monitor, T. 14 N., R. 4 E. The very irregular distribution of the Wisconsin drift is well brought out in two drill holes in sections 2 and 23 of Beaver, in which we have 135 and 37 feet of Wisconsin drift underlaid with 27 and 123 feet of pre-Wisconsin beds, respectively. In the shaft of the What Cheer Mining Co., section 30, T. 13 N., R. 6 E.,

glaciated erratics were found in the Wisconsin drift at a depth of from 82 to 89 feet. These are also found at the surface in the same section and in other parts of the county. Also in the same shaft hole, there was a bed of soft blue clay 52 feet thick, down to a depth of 82 feet, overlain by hard clay. This may represent a bed of glacial or interglacial lake clay of Wisconsin age. It is not impossible that beds of clay may be deposited by fluvio-glacial action in the same manner as sand and gravel beds. We apparently have such a relationship between Lansing and the Agricultural College east of the city.

In the beds of clay and hardpan of Wisconsin age, just described, Goff Paul went through at the old Monitor shaft, a bed of plant remains four and a half feet in thickness at a depth of 45 feet. This was over and underlaid with deposits of clay down to a depth of 81 feet, where there was a bed of sand 10 inches in thickness. This sandy bed is at the same depth as the gas sand previously mentioned as occurring in the same quarter section, which demarked the lower limits of the Wisconsin drift. This has been designated the Lower Monitor soil. The much better defined soil bed mentioned above as being found at a depth of 45 feet, I will call the Upper Monitor soil. This latter soil bed is said to have preserved the impressions of the leaves in its strata, a fact which does not indicate very strong ice action. I have also seen a few twigs from the same deposit. Apparently the same horizon as was found in the Monitor shaft, was also struck in the N. W. ¼ of the S. W. ¼ of section 28 where a bed of sand containing gas was penetrated at a depth of 40 feet. This gas burned all night. The gas sand here was both overlain by and underlaid with beds of clay of Wisconsin age. The surface deposits just east of the Monitor shaft, and on the other side of the road, contain numerous specimens of recent shells, of which a list has been furnished the Survey by Bryant Walker. It is questionable to just what extent these surface beds and the deposits above the 45-foot Upper Monitor soil are of glacial or lacustrine age. This bed may represent a local subdivision of Wisconsin age. On the other hand, the drift deposits above the Upper Monitor soil bed may represent only the Wisconsin, the drift below this horizon, and above the Lower Monitor soil bed, being Illinoian drift. However, as just stated, Prof. Chamberlin is of the opinion that the drift formation above the Lower Monitor soil is of Wisconsin age, and will be so accepted.

Pre-Wisconsin Drift. The records of 240 drill holes show beds of sand, gravel and hardpan below the upper Wisconsin beds of clay and hardpan, rather irregularly distributed, but having the greatest development where it was protected in washouts. The average thickness of these beds are 33 feet. In many localities the pre-Wisconsin drift is absent. The maximum thickness, so far as ascertained, is in section 23, T. 14 N., R. 3 E., depth 155 feet. An average of the maxima and minima of the different townships, is 62 and 122 feet respectively. These beds may have either been outwash from a pre-Wisconsin glacier ground moraine or formed in a pre-Wisconsin lacustrine area. At the Auburn shaft these beds are of sand, coal and bituminous shale, the latter having well rounded margins, as though due to fluvio-glacial action. Beds of sand make up by far the greater part of the pre-Wisconsin drift here. The amount of coal and bituminous matter both here, and in similar deposits at Auburn and South Bay City, rather point to the coal formation as furnishing material for at least a considerable portion of these beds. The sand may have its origin in part from beds

of Coal Measure sandstone, and from the erosion of the Woodville sandstone which Winchell supposed formed the cap of the coal formation.

What are apparently deposits of post-Wisconsin age, are contained in the records of two drill holes put down by Goff Paul of West Bay City. In the center of section 10, Bangor township, he went through beds of sand and muck for a depth of 30 feet, which contained a deposit of logs and shells at the bottom. This was underlain by 80 feet of clay. Another similar deposit was found at the Corbin school in West Bay City, at a depth of 30 feet, and underlain by 50 feet of clay. Unfortunately we have not been able to obtain any of the specimens of shells in either locality. In the S. E. ¼ of section 24 of Kawkawlin township, the maximum amount of sand deposited over the clay amounts to 25 feet. I have taken these beds as late glacial deposits formed during the lacustrine period of the later Quaternary. Additional information concerning the thickness of the superficial sand beds will be found in the section dealing with the distribution and structure of the surface deposits, toward the end of this chapter.

3. *Moraines; the Lake History.*

In the discussion in the preceding portion of this chapter no mention was made of the agent by means of which the drift was accumulated. During a period geologically recent a great glacier descended from eastern Canada carrying with it a great burden of material, which was in part deposited as a ground moraine along and underneath the advancing ice; in part as moraines of recession in front of the retreating ice mass. Interglacial deposits indicating at least four stages of advance and retreat have been found in the region south and west of Michigan. In this state, however, the ice action being relatively more pronounced, and nearer the center of ice origin, the earliest stages have probably been obliterated, at least in part. During the retreat of the ice mass in Michigan, the ice formed a tri-lobate structure which has been designated, beginning at the east: The Huron-Erie glacial lobe, the Saginaw lobe, and the Lake Michigan lobe. As the ice withdrew to the northward this lobate structure became more pronounced, and the interlobate moraines, as well as moraines of recession were formed, the former in the sharply reentrant angles between the moraines.

Contemporaneous with the retreat of the ice, waterlaid moraines were deposited in areas ponded by the ice mass. Such a well marked moraine trends northwest and roughly parallel with the course of the Tittabawassee river, through the southwestern portion of Williams township. In the west part of Gibson township, what may be the continuation of this moraine, designated the Saginaw and Pt. Huron moraine, swings N. 26° E. This topographic feature is relatively much more abrupt on the side away from the ice, facing the west at an angle, in Bay county. This moraine is in general parallel with the present shore line of Saginaw bay. A similar morainal structure, but one of much lesser extent, causes the south fork of the Kawkawlin river to swing to the south in Monitor township, quite analogous to the greater loop of the Tittabawassee river, formed by the more pronounced Saginaw moraine. Both these moraines increase in elevation to the northward.

As the ice sheet melted back from the rim of higher land to the south, there was ponded between this divide and the ice margin, a series of lakes, Thus we have south of the Huron-Erie lobe, Lake Maumee which primarily discharged through what is known as the Fort Wayne outlet. After a time

sufficiently long for a well defined beach to be formed on the shore of Lake Maumee, the ice of the Huron-Erie lobe melted back far enough for the waters of the lake to extend to Imlay, Michigan, where there was another place on the divide as low as the Fort Wayne outlet. A double line of discharge then followed, and the level of Lake Maumee was lowered a few feet. It remained at this level long enough to form a second beach. Likewise the melting back of the Saginaw ice lobe resulted in a lake in the plains adjacent to Saginaw bay and known as Lake Saginaw. This discharged past Pewamo into the Grand river, and is known as the Pewamo channel, or Grand river outlet. Lake Saginaw came into existence at a period subsequent to the outlet of Lake Maumee at Fort Wayne.

During the succeeding retreat of the Huron-Erie lobe the level of Lake Maumee was lowered about 30 feet, when the lake then discharged in the vicinity of Ubly, Michigan, into Lake Saginaw, receiving the discharge near Cass City. Because of the change in the geography this has been designated Lake Whittlesey.

The subsequent retreat of the ice on the "Thumb" of Michigan resulted in the coalescence of Lakes Whittlesey and Saginaw, resulting in the formation of Lake Warren which continued to discharge through the Pewamo channel, until the ice had melted back far enough to permit an outlet of the waters eastward to the Mohawk river. Lake Warren then ceased to exist but was succeeded by Lake Algonquin which occupied much of the area now represented by Lakes Superior, Michigan and Huron. This sketch may be somewhat modified by recent investigation.

During this period numerous beaches were deposited in Bay county between the land divides and the retreating ice dam. Beaches were formed at very nearly every stage of lake decline. Meander lines were run over nearly all these sand ridges, which are indicated as solid lines on the soil map. The general discontinuous formation of the sand ridges is probably due both to there being deposited on a lee shore, and to the comparative evenness of the drift.

4. *Early Beach Formations.*[1]

On the crest of the Saginaw moraine above described a well marked beach is developed at an elevation of from 825 to 830 feet at the crest, and on the top of the moraine. This beach is located in sections 7 and 18 of Gibson township and is rather interrupted in its course. This was probably formed in Lake Saginaw just outside the ice. During this period, and subsequent to the fall of the lake to about 750 feet A. T., this moraine jutted out to the south and west, forming a peninsula for some distance south and east of Estey. This may be the Belmore beach of southeastern Michigan.

On the flanks of this moraine, a beach is occasionally developed on the east and west sides of the moraine in sections 18, 19 and 30 of Gibson, where there is a rather rapid falling off of the crest of the moraine to the south. This beach is from 792 feet A. T. at the bottom, to 802 and 810 feet high at the crest.

On the west side of the Saginaw moraine the next highest line of beaches was formed at from 768 to 783 feet A. T. It is well developed in section 6 and the north half of section 7 of Gibson. This beach is occasionally interrupted by stream courses which either follow channels which have worked back and cut through the beach, or follow consequental drainage courses, the latter phase being indicated by beach lines which follow up the run banks for short distances.

[1] The elevations given are for the bottom and top.

Following the formation of the 768 foot beach, the lake extended northward as an inlet on the west side of the Saginaw moraine. In the east half of section 1, Bently township, Gladwin county, T. 18 N., R. 2 E., this beach formation faces the inlet on the west. The elevation of this beach here is from 748 to 763 feet A. T. East of this beach line and west of the moraine there is a rather narrow swamp impounded, and which extends along the entire west line of section 6 of Gibson and thence southwest into Gladwin county. This swamp is said to be interrupted by shallow bars or ridges extending across it. Crossing the Saginaw moraine to the east side, we again take up this 748 foot beach at substantially the same elevation as on the west side of the moraine. In sections 18, 19 and 31 of Gibson this beach is from 746 to 764 feet A. T. The beach here is rather more local in development, the greatest extent being in the west half of section 31. In places the ridge is interrupted by consequental intermittent drainage channels; again it merges into areas of thick white sand. I have correlated this old beach with the Upper Forest of Huron county. It may, however, prove to be the Arkona beach of southeastern Michigan. The elevation of the sand ridge in Huron county is from 744 to 774 feet A. T.

In sections 16 and 21 of Gibson, there is a sand and gravel ridge, having in places an elevation of 732 to 747 feet A. T. This would very likely make fair road metal if properly screened, and may be of value to the Bay County Stone Road Commission in their improvements in the northern part of the county.

Below this 732 foot beach there is an abandoned shore line which curves around in section 6 of Mt. Forest, and sections 20, 9 and 3 of Gibson township. The elevation varies from 716 to 721 feet at the bottom, to 727 and 733 feet at the top. In the north half of section 3 of Gibson, the beach forms a crescent opening out to the west, and is recessed by an intermittent run valley which was formerly an inlet of the lake. This beach is also finely developed on the east line of section 35, Adams township, Arenac county. I have provisionally correlated this beach with the Lower Forest in Huron county, with which it agrees fairly well in elevation. This may, however, prove to be the Upper Forest beach as originally defined. In sections 31 of Gibson and the adjoining section 6 of Mt. Forest, we have some hooked beaches probably forming delta formations, which were the debouchures of small streams which existed at about the time this Lower Forest (?) beach was being formed.

In sections 7 and 8 of Mt. Forest township there is a fine well marked beach which differs rather markedly from those heretofore described. In the south half of section 7 the top of this beach swings in at the top, the superimposed beach forming a reentrant angle toward the northwest, while the main basal beach continues on to the east-northeast. In the S. E. ¼ of section 7 this upper sand ridge gradually feathers out going northward. This feature is duplicated in the west half of section 7, except that the shore line is continued throughout the west half of the section, gradually becoming lower as we approach the county line, almost disappearing in Gladwin county. This second upper superimposed beach forms a broad V, opening out to the east, the lowest part being as described in the west half of section 7, the upper part again increasing in height where it swings northeast in the N. W. ¼ of the same section, thence swinging N. N. W. in the southwest quarter of section 6, until it finally disappears. In the N. W. ¼ of 7 there is a small reentrant beach running northwest, meeting the main beach at *about* right angles. The elevation of the bottom of the main beach in the

south half of section 7 is 710 feet A. T. At the first reentrant beach in the S. E. ¼ of section 7, the top of the basal beach is 720 and the superimposed beach 734 feet A. T. The same elevations hold in the west half of section 7, and the southwest ¼ of section 6. Mr. Lane and I are of the opinion that the upper beaches may have been formed during storm periods when Lake Warren was temporarily reelevated. It is perhaps more possible that they may represent beach deposition, during a more prolonged reelevation of Lake Warren, or they may represent fragments of beach formations produced in the ordinary course of lake subsidence. The method of coalescence, however, is rather opposed to this view. This main beach probably belongs to the upper Grassmere, well developed in Huron county. Final investigation, however, may show that it is the Lower Forest.

In sections 9 and 16 of Mt. Forest township the next well developed beach line is found at an elevation of from 675 to 690 feet A. T., the average height being about 12 feet. North and south of Mt. Forest Station the course of this beach is mainly northwest and southwest respectively, being bounded on the north by the valley of Saganing creek, on the south by White Feather creek. During the time this beach was in process of formation I believe that these present consequental drainage valleys were occupied by inlets of Lake Warren, the beach being formed on a peninsula which now forms a divide between the two streams. South of White Feather creek, and in the S. E. ¼ of the S. E. ¼ of section 17, this beach forms a fine oval formation on the south side of the run.

Westward from there in the south half of sections 18 and 19, and through the central portion of 19, there are a series of beaches which form more or less a series of continuations of the 675 foot beach above described. These beaches, however, either swing into the north and drop off eastward, or gradually feather out. We very likely have a combination of beach and delta action. The elevation of the top of these ridges is from 700 to 720 feet A. T., increasing in elevation westward.

Again taking up our 675 foot beach as developed north and south of Mt. Forest Station, we find it locally developed between two of the forks of the Saganing, northwest of Mt. Forest Station. Just east of the northwest corner of section 11, Gibson, there is a sandy elevation having an altitude of 688 feet on its crest. This beach has been correlated with the Grassmere beaches in Huron county.

On the divide between White Feather creek to the north, and Pinconning creek to the south, there is another sand ridge which terminates in the S. E. ¼ of section 16, running thence continuously southwest through section 21, the south half of section 20, and terminating near the south quarter post of section 19. The elevation of the beach on the north line of section 21, is from 673 to 680 feet A. T. This beach faces the east and south, and was contemporaneous with the extension of Lake Warren up the basin of Pinconning creek. I believe that it was developed in the same manner as the beach formation just described as occurring between White Feather creek and the valley of the Saganing. South of Pinconning creek, this ridge is well developed in section 6 of Garfield where we also have some delta hooks or spits opening out to the west, thence extending northward through section 31 of Mt. Forest township, the north half of section 32, and the S. E. ¼ of section 29, where it swings around to the northwest south of Pinconning creek. In the north half of section 31 of Mt. Forest we have some local delta formations analagous to those in section 6 of Garfield.

In the western half of Garfield township, there is another lot of beaches

which may form a continuation of the above shore line, the difference in elevation being either due to a slight falling off of the lake level, or to a slight increase in elevation northward. In the south half of section 5, Garfield, and thence east and north through the greater part of section 4, there is a well developed beach having an elevation of 667 to 674 feet A. T. This beach is also developed in the south half of section 8 and in the S. E. ¼ of section 31, Garfield, at very nearly the same elevation.

Near the head waters of Chute creek in section 4, which has been utilized as a drain east of Garfield township, and could be advantageously extended this far westward, the above shore line is comparable to the other beaches formed south of Mt. Forest Station, in that it has a general easterly trend, swinging off toward the north before running out. The shore of Lake Warren during that time must have presented a considerably indented line during its decline, with bays or inlets of the lake extending to the westward.

At the close of these beach formations there was a drop of about 10 feet in level of the lake, when another rather prolonged halt took place, during which time rather numerous interrupted shore lines were formed, extending from near the southeast corner of section 32, Williams, into Garfield township. The bottom of these beaches is from 650 to 660 feet A. T., the top from 660 to 672 feet. In Williams township this beach has only been observed on the Saginaw moraine in section 32, in Beaver township at the northwest corner of section 19, and on the north line of section 18 near the northwest corner where the elevation is 662 feet at the top. In Garfield township this beach is occasionally developed on both the east and west sides of the north fork of the Kawkawlin river, being found near the southwest corner of section 31, the northwest corner of section 30, and just west of the center of section 18. East of the river, Mr. John H. Blomshield obtained the elevation of this shore line quite accurately from a line of levels extending west almost across the township. He makes the elevation on the north line of section 16 from 660 to 669 feet A. T. It is also found at very nearly the same elevation in the east half of section 7, and the west half of section 17, Garfield, running south-southeast on top of the east valley wall of the North Fork. From the southwest quarter of section 17 the beach veers around to the west, until it abuts against the east bank of the river, in the southeast quarter of section 18. The elevation is the same here as on the north line of section 16. Subsequently the lake continued to extend up this valley, forming a well marked beach on its east divide continuously at lower elevations as far south as the northwest quarter of section 29, where the beach has an elevation of about 638 to 649 feet A. T.

In the interim between the formation of the beaches having an elevation of from 638 to 660 feet A. T. at the bottom, in the western part of Garfield, there is an occasionally well developed shore line in Williams, Beaver and Garfield townships at a height of from 644 to 654 feet A. T. In the western tier of sections forming Williams township, this beach is quite persistently developed at an elevation of from 642 to 650 feet A. T. The elevation of this beach conforms to that of the Elkton beach in Huron county formed during the later stages of Lake Warren. There is also another beach formation intimately connected with the preceding, occasionally developed in the western part of Williams, Beaver and Garfield, at a height varying from 631 to 649 feet A. T. While the top of these beaches is quite generally at an elevation of from 647 to 649 feet A. T., the elevation of the foot of the ridges varies from 631 to 642 feet above sea level. It may be that here we have off-shore bars represented in part. These beaches have substan-

tially the same elevation on the east and west sides of the moraine in the southwestern part of Williams township, and are, I presume, to be correlated in a general way with the Elkton beach developed in Huron county.

Next to the Algonquin beach, the most persistent shore line in Bay county is found at an elevation of about 633 to 625 feet A. T., at the top and bottom. On the west side of the moraine, in the southwestern part of Williams, the crest of this beach is 633 feet A. T., a short distance east of Smith's Crossing. On the east side of the same moraine, the same shore line is found slightly developed on the line between Frankenlust and Tittabawassee townships. On the east and west quarter line of section 1, Williams, there is a very pronounced ridge locally, with an elevation of from 618 to 633 feet A. T. Southeastward from here, as we shall see farther on, this beach forms a number of terraces, but is otherwise quite continuous, dropping off into the level of the Algonquin shore line. Northward, however, this beach is quite persistent in elevation. There are rather numerous sand ridges developed adjacent to the town line between Beaver and Kawkawlin. The elevation here is from 618 to 634 feet A. T. The beach lines here are occasionally very irregular, this probably being due to the open shore line to the east and west. This area is a low water laid moraine, bounded by the valleys of the North and South Forks of the Kawkawlin river, forming former inlets of the lake which gave free play to wave action, from the east and west. In sections 27, 28 and 34 of Garfield, this beach is sometimes well developed, the crest being about 642 feet A. T. In Mt. Forest township we pick it up again on the north line of section 35, the elevation there being from 624 to 634 feet A. T. On the north line of section 30, Pinconning, Mr. J. H. Blomshield made the height 636 feet at the top, where it is crossed by the so-called Pinconning stone road. This beach is also well developed in section 4 of Pinconning township, and thence northward along the Saganing road in Lincoln township, Arenac county. Mr. Lane has identified a beach at this elevation in the "Thumb," but it has not yet been given any name that I am aware of. On account of its fine development on the Saganing road in Lincoln township, Arenac county, I would suggest that the name Saganing beach be given to designate it. Mr. Blomshield made the elevation there on the north line of section 32, T. 18 N., R. 4 E., from 629 to 634 feet A. T., at the top and bottom.

In connection with the remarks made on the Saganing beach, we have had occasion to notice in section 1 of Williams township the elevation of that beach there at a height of from 618 to 633 feet A. T. From here we have a sand belt extending southeast through Monitor and Frankenlust townships, with occasional sand ridges piled up at lower and lower elevations, as the top of the lake covered moraine decreases in height southward. In the north half of section 7, Monitor, there is a beach well developed for about three-fourths of a mile extending east-southeast across the section, the top of the beach having an elevation of 623 feet A. T. near the town line. In the northeast quarter of section 7, the beach swings in and drops off, making a kind of delta hook or spit toward the south. On the line between sections 7 and 8, there is only a low slightly developed shore line which gradually becomes higher toward the east and south, swinging around and falling off around the southeast corner of section 8. On the east and west quarter line of this section the crest of this beach is 624 feet high where it is crossed by the Huron and Western R. R. In this section, the beach faces all four points of the compass, but is higher on the north and east sides. The demarkation of this beach on the north side of the river clearly shows

the extension of an inlet up the present valley at that time, on the northern shore line of which, the beach was deposited for a short distance to the westward. Again south of the river, in the S. E. ¼ of section 17, and in the N. E. ¼ of section 20, beach formation again took place at an elevation of from 611 to 621 feet A. T. In section 20 the beach is recessed by Culver creek which flows more or less parallel to the trend of the sand ridge, northeast, forming a subordinate inlet of the lake shore at that time. Again to the southeast and across the course of Culver creek, the elevation of a slightly developed ridge on the Midland stone road, and just east of the west quarter post of section 21, is or was, 605.93 A. T., as determined by Wm. Mercer in 1865, while running levels for the Bay City and Midland Plank road. In the S. W. ¼ of section 21 the elevation increases locally to about 616 feet A. T. South and east of here the beach is irregularly developed in sections 27, 34 and 35, Monitor. The top is at an elevation of about 605 feet and may be considered the southern extension of the Algonquin beach, as developed in the south part of West Bay City to the eastward. This beach extends south and somewhat east through Frankenlust township, leaving Bay county a short distance west of the southeast corner of section 14. The elevation in Frankenlust is generally from 590 to 600 feet A. T.

During the period when these, at least in part, morainal beaches and perhaps an occasional delta formation were being formed in Monitor township, another shore line was being formed to the northward in the tier of townships adjacent to Saginaw bay, and west of the Algonquin beach. This beach immediately antedates the Algonquin sand ridge, and in general is from about 610 to 620 feet A. T. at the bottom and top. It is rather discontinuous. On the east line of section 19, Kawkawlin township, such a beach formation runs in a general easterly direction south of the river at an elevation of from 612 to 620 feet A. T. Other beaches having approximately the same elevation are found in the N. E. ¼ of section 17, on the line of section 16, and in the N. W. ¼ of 15 of the same township. In section 6 of Fraser township, there is rather a complicated beach and delta? and bar formation which meanders around in this section. A spur extending across the east line of said section 6, has an elevation of from 616 to 621 feet A. T. To the south, the valley of the Chute creek drain meanders east and west, south of the old shore line. Northward, this beach conglomeration is separated from a similar formation in section 31 of Pinconning township, by the valley of Mud creek. These two sand ridges north and south of Mud creek are almost counterparts of each other in that they swing in to the north and drop off before reaching the east line of sections 6 and 31, T's. 16 and 17 N., R. 4 E., forming, I believe, spit formations. In section 32 of Pinconning township, a spur increases in elevation eastward, until it swings around and drops off to the northeast, in the N. E. ¼ of the section. In the south half of section 2 Pinconning, and about one mile west of the Algonquin beach, there are similar beach formations with an elevation of from 607 to 616 feet A. T. The same may also be seen in the north half of the same section. During this state of lake elevation, delta formation seem to have been especially active, owing to the existence of numerous small streams which worked east down the land as the lake retreated. I believe that we also have off shore bars occasionally represented of considerable elevation and spurs due to wave action and shore currents.

THE ALGONQUIN CUT BEACH IN SECTION 33 OF MERRITT TOWNSHIP.

THE ALGONQUIN BEACH, SHOWING THE SHELF ABOUT HALF WAY DOWN. LOCATED NEAR THE EAST QUARTER POST OF SECTION 15, KAWKAWLIN TOWNSHIP.

5. *The Algonquin Beach.*

This is in all respects the most well marked and continuous beach formation in Bay county, extending with scarcely an interruption its entire length north and south. During the formation of its shore lines in the southern third of the county, beach formation ceased in the vicinity of Salzburg, south of West Bay City, and we have Lake Algonquin spreading out farther to the west, forming the shore line south of the Midland stone road as already described. During this period the lake extended at least as far south as St. Charles in Saginaw county, the valley of the Saginaw river and its tributaries forming a bay which was the extension of the present Saginaw bay to the southward.

East of the Saginaw river or estuary, in Bay county, the comparatively small amount of ground above the lake at that time was formed into an island extending northwest from near the center of section 33, Merritt township. This island may have originally been a water laid moraine. In this area east of the river, are the only clear indications of beach cuttings that I have yet seen in Bay county. This is well developed on the east and west quarter line of section 33, Merritt, where the cut beach has an elevation of from 597 to 602 feet A. T. The beach in the eastern part of the section here faces the east, swinging around to the west and north in this and section 32, from where it veers off to the north and west. North of section 33, the cut beach is less pronounced in section 28, and is represented by a built up sand ridge in section 18. On the west side a similar formation may be seen in section 19. On our soil map this cut beach line is represented by hachures. In the N. E. ¼ of section 3, Portsmouth, the west side of this cut beach is again finely developed at an elevation from 595 to 603 feet A. T., as determined by spirit level. The north and east shore line of the Algonquin is again developed in section 26 of Portsmouth, and thence westward into Bay City, where it may be seen at Washington Park and just south of there. In west Bay City the Algonquin shore line swings west of the Saginaw river, before finally terminating near Salzburg.

North from West Bay City, the Algonquin beach is followed by the East Saginaw and Au Sable road throughout almost its entire extent, to the Arenac county line. In Kawkawlin township, levels have been run along the top of the beach with the object of converting it into a stone road way. The eastern front of this beach in the east central part of Kawkawlin, shows a well marked shelf at an elevation of about 593 feet A. T., the height of the top and bottom of the beach being 587 and 610. I have taken this shelf as indicating the elevation of the water when the Nipissing ? beach was in process of formation there. Toward the Kawkawlin river, this beach increases in breadth going south, the eastern front swinging nearer the bay.

On the north and south banks of Michie creek, this beach swings to the east, but is more pronounced in its western trend on the north side of the stream. Apparently Michie creek follows a consequental drainage valley, which altered the course of beach formation here during this period.

6. *Nipissing Beach.*

In the remarks made concerning the Algonquin beach in the central part of Kawkawlin township, it was observed that the lower portion of the beach there had an elevation of from 587 to 593 A. T. In Hampton township, north of what I have correlated as the Algonquin beach, there is a well marked shore line extending east and west from section 34, T. 14 N., R.

5 E., with an elevation of from 587 to 598 feet A. T., or very nearly the same height as the lower portion of the Algonquin in Kawkawlin township. Do these two localities represent a beach united in one place and separated in another? East of the Algonquin the same beach is represented by a sandy area running north and south in the north half of Merritt township. This shore line may represent Taylor's Lake Nipissing, when Lake Huron had about its present elevation. West of Saginaw bay, we have a beach starting in the north half of section 24, Kawkawlin, T. 15 N., R. 4 E., and running parallel with the bay shore for about three miles northward.

The present beach of Saginaw bay is well developed along the shore line of Hampton township, at an elevation of from 580 to 587 feet A. T. East of the lower reaches of Tobico bay we have a sand formation 16 feet high, probably due to both wave and wind action.

7. *Distribution and Structure of Surface Deposits. Shell Beds.*

Adjacent to the beach lines above described, are considerable areas of sandy soil gradating into loam and gravelly deposits. These areas are printed orange yellow on the soil map, the thickness of the sandy beds being approximately indicated by increase or decrease in the amount of stippling, *i. e.*, the greater the amount of sand, the heavier the shading. Such sandy areas will be noted in the area adjacent to Saginaw bay, being bounded on the west by an area of clay soil, which increases in width toward the south, including the greater part of Monitor, Williams and Frankenlust townships. These clay areas have been left uncolored on the soil map. North of Williams township, the western tier of townships generally contain a greater or less amount of sand, in some places amounting only to a veneer of surface covering over the clay subsoil, which increases the ease of working, making it especially adapted for root crops. This is especially true of the soils in Gibson township, which produce fine crops of potatoes, hay, clover, etc. There are also areas in the western tier of townships where the clay comes to the surface in front of the beach lines, but they are of rather limited extent. East of the Saginaw river there are only limited areas occupied by sandy deposits, the greater part being clay with some muck land.

In connection with the remarks made on the drift and its subdivisions, we had occasion to notice some rather heavy beds of lake sands deposited in West Bay City, and adjacent to Saginaw bay. The following data obtained from drill records, will serve to give further information where we have beds of sand, for the most part adjacent to, or forming sand ridges. In sections 1, 2, 12, and 13 of Frankenlust township, we have from 2 to 20 feet of sand, as in the N. W. ¼ of section 13. Taking into account the elevation of the Algonquin beach here, and that of the clay beds in close proximity, it would rather seem that the sand was deposited in a swale. In sections 7 and 27 of T. 14 N., R. 4 E., we have from 5 to 20 feet of sand laid down in the area traversed by the sand belt running northwest through Monitor, forming a continuation of the Frankenlust deposits just mentioned. In T. 14 N., R. 5 E., we have from 3 to 33 feet of sand adjacent to the bay shore, and the Algonquin beach east and west of the Saginaw river. In the record showing the greatest amount of sand just north of the southeast corner of section 17, and near the crest of the Algonquin beach, we have some 15 feet more sand, than the elevation of the beach there. Also the bottom of the sand is lower than the adjacent surface clays to the northeast. In T. 15 N., R's. 4 and 5 E., east of the State road, and west of Sagi-

GLACIATED ERRATIC IN THE NORTHWEST QUARTER OF THE NORTHEAST QUARTER OF SECTION 34, T. 14 N., R. 5 E.

naw and Tobico bays, we have 17 drill holes for coal, which have from 6 to 25 feet of sand as in section 24, T. 15 N., R. 4 E. In the adjoining sections to the north and east the drift varies from 7 to 19 feet in depth. In the lower portions of T's. 16 and 17 N., R. 3 E., we have three drill holes which show from 6 to 8 feet of sand on the level, possibly delta or lake bottom sands.

Muck land occupies rather restricted areas in this county. In the southeastern part of Merritt there are considerable areas of this soil either underlain by sand or clay, which will be found separated on the map. Other limited tracts are found west of the Algonquin beach line in Kawkawlin township, and west of the south part of West Bay City. There are also areas in the southwestern part of Williams township, and thence northward in the western tier of townships, especially in Mt. Forest township.

In Kawkawlin township this soil is the result of the accumulation of vegetable material in swamp land formed back of the Algonquin beach. These areas are printed in brown on our soil map. East of the Saginaw river these beds of muck often contain shell remains identical with modern species. A list of such species as I had time to collect will be found printed further on.

The following is a list of localities from which recent shells were collected with descriptions of the same.

Locality No. 1.

On the east line of section 23, Hampton township, and extending south from Nebobish avenue almost to the section corner, are interesting deposits of drift exposed on the west side of the road, and for the most part south of the Nipissing (?) sand ridge which crosses the section line there. Beginning toward the south, there are thin beds of stratified sand and gravel at the top from 10 to 20 inches in thickness and underlain by a bed of muck, which in turn rests on the clay. This bed of muck is formed south of the beach, and is very likely the result of former swamp formation during the Nipissing or late Algonquin epoch. Both the beds of stratified sand and gravel overlying the muck, and in the underlying clay are numerous shells which point to a lacustrine origin. There was probably considerable oscillation of the lake level during that time. Associated with the shell bearing beds were specimens of Devonian corals, which may have either been transported from the erosion of nearby deposits or carried a greater distance by floating ice. The specimens of shells from the underlying clay are considerably worn.

Locality No. 2.

Near the northeast corner of section 33, Monitor, is a depauperised fanua in a sandy loam deposit containing cobble stones. The shells are well preserved when found in the matrix, and do not indicate any action of the shore ice. During the Linear Survey, and to a lesser extent at the present time, this area was occupied by swamp land formed back of the Algonquin beach to the eastward. The elevation is about 601 feet A. T. These surface deposits are probably of Algonquin age.

Locality No. 3.

In a drain about three feet deep on the west line of the northwest quarter of section 7, T. 13 N., R. 5 E., I collected numerous specimens of shells in

a silt clay, either of lake origin, or deposited more recently, by the river. The elevation is about 587 feet above sea level.

Locality No. 4.

Additional species were collected in a ditch from 12 to 18 inches deep, on the line between sections 9 and 10, T. 13 N., R. 5 E., and south of the quarter post. The deposit was clay containing small pebbles. Specimens were also seen in the same section further east. The elevation here is about 584 feet A. T. During the recent high water of the spring of 1904, this area was entirely flooded. This is on the border of the prairie region.

Locality No. 5.

This is on the north line of section 10, Merritt, and not far east of the northwest corner. In a drain which was being dug at that time, during the summer of 1900, there was exposed about four and a half feet of white sand at the top, underlain by a thin layer of muck above the clay. The section is not unlike that given in locality No. 1. This deposit may have been formed during the period of the Nipissing (?) lake. At any rate the elevation of this shell bed is quite approximately the same as in the first locality mentioned. As I remember, the sand beds here were deposited in a swale trending northward in the underlying clay. The muck probably represents a swamp deposit of Nipissing (?) age, or late Algonquin.

Locality No. 6.

These specimens were found in beds of muck and in the underlying clay, in a ditch on the west line of the N. W. ¼ of section 31, Merritt township. The elevation is from 586 to 588 feet A. T.

I have also seen shells in superficial sand deposits along an old tram road in the east half of section 34 of Gibson township, at an elevation of about 670 feet A. T. No collections were made here.

The following species were identified by Mr. Bryant Walker of Detroit with the exception of the Pisidia, and a few other species, which were sent to Dr. V. Sterki. The latter identifications are indicated by an asterisk placed before the species. An asterisk placed after the author of the species shows its occurrence in Huron county. Out of some 52 species identified in Bay county, 22 species are common to both localities.

Concerning the collection in general, Mr. Walker writes as follows: "With the exception of the new form of Pisidium from Monitor (Township—locality 2), there is nothing of special remark in this material. As a whole it is substantially the same as the existing fauna. There is some individual variation of course, but no more than would be expected in an equal amount of recent material; nothing so general and characteristic as to make a noticeable feature in the fauna."

The locality numbers used in this list correspond to those used in the text.

	1.	2.	3.	4.	5.	6.
Amnicola limosa Say*			*	*		
Amnicola lustrica Pils				*		
Amnicola walkeri Pils			*	*		
Bifidaria pentodon Say			*			
Calyculina securis Pme		*				
Campeloma decisa Say				*		
Campeloma integra Say						*
Goniobasis livescens Mke*	*		*	*	*	*
Limnaea caperata Say			*	*		
Limnaea catascopium Say*	*					
Limnaea desidiosa Say*		*		*		
Limnaea desidiosa, var. decampii, Streng*	*					
Limnaea humilis Say			*			
Limnaea palustris Mull*		*	*			
Limnaea reflexa Say*				*		*
Limnaea stagnalis Lea*						*
Physa elliptica Lea		*	*			
Physa gyrina, var. hildrethiana, Lea*	*			*		*
Physa heterostropha Say				*		
*Pisidium affine St	*			*		*
Pisidium compressum Pme	*		*	*		*
Pisidium contortum Pme		*				
*Pisidium medianum St				*		
*Pisidium rotundatum Pme		*				
*Pisidium sargenti St				*		
Pisidium scutellatum Sterki		*	*	*		*
*Pisidium splendidulum Sterki				*		
*Pisidium trapezoideum Sterki	*					
Pisidium variabile Pme	*	*	*			
*Pisidium ventricosum Pme		*				
*Pisidium ventricosum, var. costatum, St		*				
*Pisidium virginicum Bgt	*					
Planorbis bicarinatus Say*	*			*		*
Planorbis campanulatus Say*				*		*
Planorbis deflectus Say				*		*
Planorbis exacutus Say				*		
Planorbis hirsutus Ged			*	*		
Planorbis parvus Say*		*	*	*		
Planorbis trivolvis Say	*	*	*	*		*
Polygyra monodon Rack			*	*		
Polygyra multilineata Say				*		
Sedmentina armigera Say*			*	*		
*Sphaerium flavum Pme	*					*
Sphaerium occidentale Pme			*			*
Sphaerium simile Say	*			*		*
Succinea avara Say			*			
Succinea retusa Lea*	*	*	*	*		*
Unio gibbosus Bar*?	*					
Valvata sincera Say		*				
Valvata tricarinata Say*			*	*		*
Vertigo spr			*			
Zonitoides minusculus Binn			*			

While these beds of sand, clay and muck containing shells represent late lacustrine deposits, it has not been found possible to systematically separate them from other argillaceous deposits in different parts of the county. Concerning the clay shell-bearing soils themselves I have not yet seen any beds above an elevation of 601 feet A. T., which are found described in locality 2. However, in the north half of section 23 of Kawkawlin township, I noticed a glacial erratic in the clay at about 587 feet A. T. Thus it will be seen that it is not possible to separate superficial lake clay de-

posits on account of the elevation of such beds. Also in section 31 of Merritt, glaciated erratics were found on the surface at an elevation of about 10 feet above the bay and Saginaw river or at 590 feet A. T. Mention has already been made of a buried glaciated boulder in the same section taken from the What Cheer shaft.

At other localities glaciated erratics have been found in a number of places. In the S. E. ¼ of section 31, Fraser, there is a small glaciated erratic at an elevation of 620 feet A. T. Likewise there are glaciated pebbles in section 29 of Pinconning. In Gibson township similar glaciated erratics were found in the west half of section 25, and in section 15. A granite boulder 10 feet long was found about three-tenths of a mile east of the north quarter post of section 22, Gibson township. Recently I noticed a fair sized glaciated erratic on the west side of the Algonquin shore line north of the stone road going east from the southern part of Bay City and west of the Tuscola stone road.

There are numerous erratics yet scattered over the surface of Bay county notwithstanding the extent to which they have been removed to facilitate tillage.

In the northwestern part of Williams township, the southern and eastern part of Beaver, the southeastern part of Garfield, and occasionally as far north as the central part of Gibson township, pot or kettle holes may be seen. In the northwestern part of Williams they are especially numerous. In form they are generally narrowly elliptical, the axis of the ellipse having a general north and south course. In such a pot hole a mastodon was found near the southwest corner of section 3, Williams, a notice of which appeared on page 253 of the annual report of the Geological Survey for 1901. The skeleton was buried three feet below the surface. The general formation and uniformity of these pot holes appears to be due to some general physical agency such as the ice. They may be due to the melting of buried ice masses or variation in the structure of the underlying soils producing the same result. Pot holes in general are supposed to have been produced by the accumulation of washed soils around bergs, which afterward melted, leaving an undrained hollow. The depth of water supposed to be on the surface of Bay county at that time rather precludes this explanation. To make this survey of the drift of Bay county fairly complete it only remains to be noted that drift corals of Devonian age have occasionally been seen on the superficial soil deposits of Gibson township.

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CHAPTER V.

PHYSICAL GEOGRAPHY AND DRAINAGE.

1. *Introduction, Acknowledgements.*

In chapters 2, 3 and 4 we had occasion to investigate the geology of the Devonian and Carboniferous formations, and the coal and Quaternary deposits in greater detail, as they are developed in Bay county. The resultant of the processes which operated during that time, and the activities of physical agencies during the present, embrace the subject of physical geography as discussed in this chapter. In a sense physical geography is to geology, as physiology is to anatomy, the essential element being activity in its effect on geological deposits, as embodied in dynamic agencies. The agents as far as will be considered here, are the water, precipitation, the results and changes of temperature. These factors and the resultants of earlier geological conditions, enter largely into the relief of the surface of Bay county, now to be discussed. Hutton in his treatise on the "Theory of the Earth," 1803, was the first to recognize the importance of physical geography as a key to past geological results. Moreover, physical geography furnishes an explanation of many of the geographical features of Bay county, and I trust that this information will be useful to teachers in making their instruction more real, by the introduction of familiar illustrations.

In connection with this chapter I desire to acknowledge my indebtedness to Captain William Barrett, at that time Supervisor from West Bay City, who was the means of giving me access to the records in the County Drain Commissioner's office. To the Drain Commissioner at that time, Mr. Lawrence McHugh, I am very glad to express my thanks for his generosity and accommodation. Additional drain records were obtained from Mr. J. Madison Johnston, who has been engaged in his profession of surveying for the last 40 years. Mr. John H. Kelly and Mr. Henry C. Thompson, former Drain Commissioners of Bay county, have both allowed me free access to their records, which have filled in a good many gaps. Mr. E. L. Dunbar, Superintendent of the Bay City Water Works Department, has given the Survey several valuable lines of levels. Mr. Dunbar also has the records of Mr. Wm. Mercer, former City Engineer of Bay City, which have been of very considerable use in the preparation of the contour map. The survey is especially indebted to Mr. John H. Blomshield, Engineer of the Bay County Bridge Commission, for the use of his office, and the numerous lines of drain levels which he ran for the most part about 20 years ago. Mr. Blomshield and Mr. H. C. Thompson have also run almost all the levels for the Bay county stone road Commission, of which I obtained almost complete records. Altogether the levels of 121 drain lines were obtained, along with the levels of 38 lines of streets, roads, and railroads. In this connection it would be well to emphasize the necessity of at least a certain amount of order, continuity and administration in the county drain work. As I believe the law demands, files showing the location, elevation and assessment

of each drain are required to be on file in the County Clerk's office. As a matter of fact, not only are these records almost entirely lacking, but the levels of very nearly half the drains and most of the maps are or were, missing in the Drain Commissioner's office. This is probably due to the lack of permanent quarters for that department, which should be remedied. In the matter of drain assessments there was oft times, as the contour map shows, an almost total lack of justice, and while the contour map in this report may not always be sufficiently detailed and accurate, I believe that it will be of a very considerable use in this, as in other regards besides, as it has been in Ohio. I have endeavored to give the drainage area of all such drains as are enumerated. The expense of this report would be paid several times over if these data are properly used.

2. *Temperature and Precipitation.—Land and Water Temperature Variations.*

The mean temperature at Bay City is 46.3° F., or nine-tenths of a degree lower than for Saginaw. The maximum and minimum vary from 70.1° F. to 20.4° F., as in July and February respectively. The cumulative effect of the heat apparently manifests itself sooner than that of the cold, making the fall longer. In the accompanying table showing the mean temperature at Bay City, the average for certain missing months is given in brackets. These averages were obtained by first striking a monthly average of such records as we were able to obtain relative to Bay City. The differences of these averages at Saginaw was subtracted from the average of the month at the latter place, and taken as the mean for the missing month at Bay City. Additional tables were also prepared from the monthly reports of the Weather Bureau showing the maximum and minimum temperature of Bay City.

Mean Temperature at Bay City, Mich.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Average.
1896.....	.....	.....	.....	50	{63.6 {63.9	65.8 67.2	70.5 70.7	68.3 69.3	57.0 57.4	45.0	37.2	38.2	....
1897.....	25.7	(25.1)	30.1	46.3	(54.6)	(62.3)	73.0	65.4	64.4	49.4	(34.6)	25.7	46.4
1898.....	25.0	25.8	35.4	41.2	56.2	66.5	70.2	68.2	64.1	48.8	34.2	24.1	46.6
1899.....	20.1	16.2	30.0	48.0	57.4	67.6	68.4	69.4	57.4	53.8	41.2	26.6	46.4
1900.....	25.4	17.6	23.0	45.8	57.2	65.0	70.4	74.4	65.3	57.6	37.2	30.0	47.4
1901.....	23.3	(15.3)	29.9	44.1	56.2	(66.8)	75.0	68.4	61.0	50.8	32.9	21.8	45.4
1902.....	24.6	(21.7)	38.2	44.7	56.8	62.2	70.8	65.0	59.9	49.7	44.1	24.4	46.8
1903.....	22.0	21.3	39.6	44.8	57.8	59.2	70.7	64.4	60.8	51.6	33.6	21.1	45.6
Mean....	23.7	20.4	32.6	45.3	58.2	64.7	70.1	68.1	60.8	50.8	36.9	26.5	46.3

Maximum and Minimum Temperature at Bay City, Mich.

Year.	January.	February.	March.	April.	May.	June.
1896	.....	.....	.....	84, 19	{ 89, 38 { 91, 39	89, 40 94, 42
1897	54, −6	.....	.....	73, 20	79, —	93, —
1898	40, −2	47, −12	62, 11	67, 16	78, 34	92, 44
1899	53, −13	51, −21	55, 12	86, —	82, 35	91, 45
1900	48, −7	62, −12	49, −4	80, 22	85, 28	92, 40
1901	44, 1	—, —	57, 0	84, 23	82, 32	—, 35
1902	54, 2	—, −2	68, 6	82, 22	89, 23	87, 40
1903	46, 0	42, −12	74, 13	85, 19	85, 24	88, 35

Maximum and Minimum Temperature at Bay City, Mich.

Year.	July.	August.	September.	October.	November.	December.
1896	{ 92, 48 { 94, 48	94, 42 96, 43	84, 28 84, 29	74, 20	66, 9	52, 3
1897	100, 53	87, 44	95, 34	78, 31	—, 14	55, −8
1898	94, 42	93, 47	93, 36	84, 26	67, 13	44, 3
1899	89, 50	94, 47	91, 26	85, 28	60, 26	57, −7
1900	96, 45	99, 51	91, 38	87, 29	68, 20	50, 10
1901	98, 52	91, 48	90, 34	80, 25	60, 9	55, −8
1902	91, 48	85, 47	83, 38	71, 27	68, 19	44, −2
1903	95, 40	85, 40	90, 33	75, 25	70, 12	40, 1

The average amount of precipitation is about 34 inches, the annual variation between 1896 and 1903 inclusive, being from about 29 to 44 inches, as in 1900 and 1902 respectively. The greatest amount of rainfall is during July, with the least in February. Traces of snow come in October, and rarely as late as in May, the greatest amount falling in February when the rain precipitation is least. The average amount of annual snowfall was nearly 28.9 inches during the years 1896-1903, inclusive, varying from 12.5 to 36.2 inches during the years 1900 and 1902 respectively. Inasmuch, however, as our annual averages divide the winter into unequal parts the entire amount of snowfall would be changed somewhat. The following tables exhibit the entire amount of precipitation.

Rain and Snowfall at Bay City, Mich.

Year.	January.	February.	March.	April.	May.	June.
1896	.....	.....	.....	2.54, ...	{ 4.40, ... { 3.52, ...	1.49, ... 1.26, ...
1897	3.70, 6.0	0.61, 5.8	4.26, 14.0	3.61, T	3.65, ...	0.64, ...
1898	2.57, 17.0	....., ...	3.52, 0.0	1.92, T	2.34, ...	4.53, ...
1899	1.93, 4.0	1.10, 2.5	3.02, 27.5	1.21, ...	4.72, ...	1.91, ...
1900	1.49, 3.2	2.94, 15.5	1.39, 9.0	2.07, 3.0	2.56, T	1.43, ...
1901	1.15, 7.5	....., ...	3.25, 3.0	1.05, 2.0	2.35, ...	0.85, ...
1902	0.08, 0.8	0.43, 3.5	6.09, 1.0	1.11, T	4.32, ...	6.50, ...
1903	1.53, 6.0	2.55, 17.0	1.26, T	4.77, T	1.95, ...	2.40, ...
Average	1.78, 6.4	1.53, 8.5	3.25, 7.8	2.36, 0.6	3.31, ...	2.33, ...

Rain and Snowfall at Bay City, Mich.

Year.	July.	August.	September.	October.	November.	December.	Total for year.
1896.....	2.10, ... 0.74, ...	2.75, ... 3.05, ...	4.65, ... 4.24, ...	0.58, ..	3.12, 2.0	0.71, 3.5	.....
1897.....	10.10, ...	1.16, ...	0.69, ...	3.24, ...	2.30, T	2.15, 8.2	36.11, 34.0
1898.....	1.38, ...	2.96, ...	1.97, ...	4.56, T	2.59, 8.0	1.46, 6.0	29. 8, 31.0
1899.....	7.04, ...	0.22, ...	3.73, ...	4.73, ...	1.76, ...	1.95, 2.7	33.32, 36.7
1900.....	4.65, ...	4.88, ...	1.27, ...	3.57, ...	2.97, 5.5	T T	29.22, 36.2
1901.....	4.38, ...	4.57, ...	0.23, ...	4.10, T	0.85, T	1.90, 4.0	24.68, 16.5
1902.....	8.46, ...	2.55, ...	4.10, ...	4.38, ...	2.44, 1.2	3.18, 6.0	44.14, 12.5
1903.....	0.60, ...	7.25, ...	8.05, ...	3.90, ...	1.95, 3.5	1.45, 9.0	37.66, 35.5
Average.....	4.38, ...	3.26, ...	3.24, ...	3.63, ...	2.24, 2.5	1.60, 4.9	33.56, 28.9

LAND AND WATER TEMPERATURE VARIATION. An examination of the yearly mean isothermal lines for lower Michigan as given in the Michigan Section of the Climate and Crop Service of the U. S. Weather Bureau, in co-operation with the Michigan State Weather service, affords some suggestive comparisons. We have for instance, prepared the following table showing the higher latitude of the isotherms on the west shore line of lower Michigan, as compared to the east, for the years 1900-1904 inclusive.

Year.	Degree.	Miles farther north on west shore.
1900	48	10
1900	46	20
1901	46	31
1901	44	60
1902	48	1
1902	46	52
1902	44	60
1903	46	108
1903	44	66
1904	44	54
1904	43	30
1904	42	42
1904	41	78
1904	40	40

From this data we see that the isotherm of 48° has an average distance of six miles further north on the west shore than on the east; that of 46° of 53 miles; of 44°, 60 miles; of 42° and 40° for the year 1904, of 42 and 40 miles respectively. An average of these combined data show the same temperature averages extending 46 miles more northward on the west side of lower Michigan.

As an exception to this general rule of higher isothermal lines on the western shore of lower Michigan, the isotherm of 48° for 1903 is eight miles farther north in Macomb county adjacent to Lake St. Clair, than where Van Buren county is washed by the waters of Lake Michigan. Likewise during 1904, the line for 45° is 16 miles farther south in Berrien county, than in Macomb. Both these isothermals, however, show some deflection to the northward, on approaching the Lake Michigan shore.

Comparing the isothermals on the east and west sides of Lake Michigan,

as given in the reports of the Section Directors of Michigan and Wisconsin, we obtain the following results:

Year.	Degree.	Miles farther south in Michigan.	Miles farther north in Michigan.
1900	48	5	.....
1900	46	.....	38
1900	42	.....	25
1901	48	23	.....
1901	46	.....	16
1902	48	26	.....
1902	46	.....	50
1903	46	.....	100
1903	44	.....	88
1904	44	4	.....
1904	42	.....	33

Taking into account the negative factor in this comparison, the results show the average temperature on the east side of the lake 36 miles farther north than in Wisconsin. None of these results compare very closely with those given by Alexander Winchell in Walling's atlas. The object of this section is to present some data showing the cause of this atmospheric variation. In obtaining our temperature observations I used an H. J. Green thermometer No. 7529. The readings were taken on the west side of Saginaw bay and east of Tobico inlet, northwest of Bay City. Less than five minutes elapsed between the readings on the land and in the water. During August 12, 13, 15, 16, 17, and 18, 1904, the thermometer was read at 5:30, 7:30-10:30 hourly, and at 11:15 A. M., and hourly from 1:00 to 7:00 P. M., excepting at 6:00 P. M. August 22 and 23 readings were taken consecutively from 1:00 P. M. to 11:15 A. M. the following morning. August 25 and 26 the thermometer was read from 5:30 A. M. to 5:30 A. M., being consecutive for 24 hours ending August 26. Judging from the last two series of observations the maxima and minima temperatures were very nearly obtained by the readings taken from 5:30 A. M. to 7:00 P. M. Our land and water temperature at Tobico will be compared with the maxima and minima readings taken by the Weather Bureau at Bay City, Midland, Saginaw, and Hayes. From Tobico, Bay City is situated six miles to the southeast, Midland 16 miles west and somewhat south, Saginaw 19 miles almost due south, Hayes 36 miles east-northeast across Saginaw bay. These readings can be most conveniently presented by tables

Maximum and Minimum, August 12, 1904.

Bay City.	Midland.	Saginaw.	Hayes.	Tobico, air.	Saginaw bay.
80	80	80	78	79	73.5
48	58	48	44	51	68.0
32	22	32	34	28	5.5

The variation of water temperature at Tobico compared with the land is 19%. The winds were light and variable. The average of my land temperatures on the day in question was 71°, of the water 72°.

Maximum and Minimum, August 15, 1904.

Bay City.	Midland.	Saginaw.	Hayes.	Tobico, air.	Saginaw bay.
77	78	87	82	80.5+	71+
47	58	63	61	66	68
30	20	24	21	14.5	3

The day was cloudy until 9:30 A. M. Our readings ceased at 11:15 A. M. The air temperature at Tobico increased 14.5°; that of the bay 3° or 20.7%. The average of the six readings taken during the forenoon was 71.6° for the land, and 68.9° for the water. The wind at Saginaw and Midland was from the southwest; from the north at Bay City.

Maximum and Minimum, August 15, 1904.

Bay City.	Midland.	Saginaw.	Hayes.	Tobico, air.	Saginaw bay.
86	76	89	86	83	74
63	52	66	59	62	67
23	24	23	27	21	7

The day was clear with westerly winds blowing. From 5 A. M. to 2 P. M. the Tobico water temperature increase was 33% of that of the land. Locally the result in modifying the temperature at Tobico is somewhat apparent, but we would rather expect the variation at Midland and Hayes almost reversed.

Maximum and Minimum, August 16, 1904.

Bay City.	Midland.	Saginaw.	Hayes.	Tobico, air.	Saginaw bay.
81	70	83	78	79.7	77.0
60	.....	61	56	62	69
21	20	22	22	17.7	8

It rained during the night of August 15 and 16, clearing up by noon time, the wind apparently being down the bay, or from the northeast during the period of fair weather. At Bay City, Midland and Hayes the wind was from the northwest; from the southwest at Saginaw. The water temperature increased 45% of the range of the air. This very considerably higher ratio of the water is very likely due to the action of the wind sweeping down the bay, exposing relatively a larger water surface to the wind within a unit of area, and to the action of the waves in entrapping particles of air. Not having the temperature of the rain water which fell during the night it is impossible to state how this would modify that of the water in the bay. The water temperatures during the day only dropped 3° from 7:00 P. M. to 5:30 A. M. the next morning, while that of the land fell 9° in the same interval.

It is apparent that under such conditions we would have the climate somewhat modified, the main tendency being to check sudden variations near the adjacent windward shore, and to increase the temperature, especially at night. With the exception of Midland the land temperatures increase going away from the bay. The highest minimum temperature is adjacent to the shore as we should expect; away from there it is irregular as can be seen from the table. Our average land temperature at Tobico was 71.25°, of the water 73.07°.

Maximum and Minimum, August 17, 1904.

Bay City.	Midland.	Saginaw.	Hayes.	Tobico, air.	Saginaw bay.
75.....	74	82	?	80	77
60.....	50	60	?	62	71
15.....	24	22	.....	18	6

This day was clear with the wind at Tobico from the west during the greater part of the forenoon, and shifting to the north at 1 P. M. At Bay City the wind was from the northeast, at Saginaw from the southwest, and from the west at Midland. The increase of water temperature was 33% of the range of that of the air at Tobico, being somewhat intermediate between periods when the wind is off and on shore. The main trend of the bay is northeast. It is apparent that this northerly wind was quite pronounced in ameliorating the temperature of Bay City, which is situated directly south of the bay about two miles, and more nearly in the path of the wind than our station at Tobico. It is also noticeable that at Saginaw some 14 miles further south, the benefit is much less apparent. The still greater amount of variation at Midland is apparently explained by its location and the westerly breeze blowing there. These on-shore winds are only pronounced in modifying climatic conditions within relatively circumscribed areas. This deduction is not only bourne out in part by our own data, but by an examination of the isothermal charts of lower Michigan for 1903 and 1904, to which we have already had occasion to refer. An average of 12 readings on land and water, gives 72.8° for the former, and 73.9° for the latter, at our stations near Tobico bay. Also I believe that an examination of the observations for August 17, and other sources of information, show that insular climates are more pronouncedly influenced in preventing minima temperatures, than the reverse. This is especially true in the late summer and fall. In the spring and early summer we would expect the reverse. As to the former conclusion, as we shall see farther on, this is due to the very considerable capacity water has of absorbing heat during the day and retaining the same to a greater capacity at night.

Maximum and Minimum, August 18, 1904.

Bay City.	Midland.	Saginaw.	Hayes.	Tobico, air.	Saginaw bay.
75.....	78	78	80	75.2	75.3
58.....	60	59	45	57.0	66.0
17.....	18	19	35	18.2	9.3

During this day the sky was clear with an easterly wind blowing on shore at Tobico; at Bay City and Saginaw from the northeast, at Midland from the northwest. The Weather Bureau record at Hayes is wanting in this respect. It will be noted from the above tables, that the temperature range of Saginaw bay increased 50% of the air. Comparing this with those previously discussed, it was noted that with a north wind blowing diagonally across the bay, that the ratio of water to land temperature was 33%, with a northeasterly wind blowing down the bay of 45%, while that from the east, as just given, is 50%. While theoretically we might expect the greatest increase of water temperature with a full breeze coming from the northeast down the main trend of the bay, this result is very probably modified by the shallow waters of the lower reaches of Saginaw bay, giving greater play to wind action. This on shore action, as noted above, is not only pronounced in increasing relatively the greater warmth of the water, but also, *pari passu*, in modifying proportionately that of the adjacent land to the west. It is also true that this modification of temperature would be greater during the night on account of the greater radiation of the heat from the land. The result at Hayes, compared with Midland, is especially noticeable in variation of temperature at the former place, probably due to this easterly wind.

Maximum and Minimum, August 22, 23, 1904.

Bay City.	Midland.	Saginaw.	Hayes.	Tobico, air.	Saginaw bay.
75.....	78	78	83	76	74.5
45.....	58	44	45	50	66
30.....	20	34	38	26	8.5

During portions of these two days observations were taken consecutively from 1:00 P. M. to 11:15 A. M. Our maxima readings were taken August 22, minima readings the following morning. The weather was clear, wind from the northwest, shifting to the west at about 7 A. M., August 23. At Bay City and Midland the wind blew from the southeast and south, at Saginaw from the southwest. During this time the variation of water temperature compared to that of the air was 32.6%. During the forenoon of the 23d the air temperature increased 24° by 11:15 A. M., and the water increased 5.7° within the same time, or 23.75%. While during the afternoon the maximum air temperature was 1.8° greater than the water, at 5:30 A. M. the next morning the lowest air temperature was 16° less than the minimum water temperature, showing the very considerable capacity of the water to retain heat during the night, and the ameliorating result that it would have on the land with an on shore wind blowing. An average of our air and water temperatures near Tobico are respectively 64.5° and 69.9° during the entire period of about 24 hours.

Maximum and Minimum, August 25, 26, 1904.

Bay City.	Midland.	Saginaw.	Hayes.	Tobico, air.	Saginaw bay.
83.....	80	82	80	85	75.5
44.....	60	43	?	46	63.3
39.....	20	39	.....	39	12.2

During the 24 hours ending at 5:30 A. M., August 26, 1904, we have a continuous series of air and water temperatures. At Tobico the weather was fair, with quite a strong westerly wind blowing throughout that time. At Bay City, Midland and Saginaw, the wind was also from the west and southwest. Our maxima readings were taken on the 25th, the minima on the 26th. The average of 18 readings give an air temperature of 67.07°, that of the water being 69.9° for the same time. During the 25th the air and water temperatures increased 13° and 7.5° respectively, the ratio being 57.6%, followed by a minimum drop of 39° and 12.2° of the air and water at 5 A. M. on the 26th of the following morning, or only 31% of change of the water relative to the air. Air and water temperatures taken simultaneously on the other side of the bay would be desirable for comparison here. These readings, however, clearly show the property water has of absorbing and retaining heat.

In the period which is covered by our observations the average of water temperature was 72.11°, that of the air being 72.38°. It is more probable, however, as shown by our readings for 24 hours, that the average water temperature is about 4° greater during the latter part of August than that of the air. The ratio of change of water temperature relative to that of the air is less than 34.4%. In this factor, taking into account the prevailing southwesterly winds, is at least a partial explanation of the insular climate of lower Michigan. Moreover, the temperature of the water, as a rule, being greater than that of the air from about 7 o'clock in the evening until about 9 o'clock the following day, the tendency would be to increase the temperature of the adjacent shores. On the other hand, the air temperature being greater during the remainder of the day, the water would tend to establish an equilibrium negatively, the two means of variation probably approaching that of the average of the two factors, air and water. The more prolonged period of greater water temperature is doubtless the greater factor in this question.

The following tables are appended showing the maxima and minima temperatures of West Saginaw, Bay City and Midland, as furnished by C. F. Schneider of the State Weather Bureau, with our own observations near Tobico.

1904.	Aug. 12.		Aug. 13.		Aug. 15.		Aug. 16.		Aug. 17.		Aug. 18.		Aug. 22.		Aug. 23.		Aug. 25.		Aug. 26.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Bay City.....	80	48	77	47	86	63	81	60	75	60	75	58	75	.....	.....	45	83	.....	.....	44
Midland.....	80	58	78	58	76	52	70	50	74	50	78	60	78	.....	.....	58	80	.....	.....	60
Saginaw.....	80	48	87	63	89	66	83	61	82	60	78	59	78	.....	.....	44	82	.....	.....	43
Hayes.....	78	44	82	61	86	59	78	56	.....	.....	80	45	83	.....	.....	45	80	.....	.....	.....
Tobico.....	79	51	80.5+	66	83	62	79.7	62	80	62	75.2	57	76	.....	.....	50	85	.....	.....	46
Saginaw bay..	73.5	68	71+	68	74	67	77	69	77	71	75.3	66	74.5	.....	.....	66	75.5	.....	.....	63.3

Air and Water Temperature near Bay City.

1904.	Aug. 12.		Aug. 13.		Aug. 15.		Aug. 16.		Aug. 17.		Aug. 18.		Aug. 22.		Aug. 23.		Aug. 25.		Aug. 26.	
	Tobico, air.	Saginaw bay.	Tobico, air.	Saginaw bay.	Tobico, air.	Saginaw bay.	Tobico, air.	Saginaw bay.	Tobico, air.	Saginaw bay.	Tobico, air.	Saginaw bay.	Tobico, air.	Saginaw bay.	Tobico, air.	Saginaw bay.	Tobico, air.	Saginaw bay.	Tobico, air.	Saginaw bay.
1:00 A. M.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	53	67.3	....	....	48	65
3:00 A. M.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	51	66.5	....	....	46	64
5:00 A. M.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	46	63.3
5:30 A. M.	51	68	66	68	62	67	62	69	62	71	57	66	....	....	50	66	72	68	46.5	64
7:30 A. M.	64.5	69	69.3	68.3	66.2	68.6	65	69	67.4	71.3	65.4	68	....	....	61	67	76	70	....	....
8:30 A. M.	....	....	69	68.5	71	71	62	69.3	72.5	72.5	65.5	68.6	....	....	69	68	79	71.5	....	....
9:30 A. M.	72.5	71	71.4	69	73.5	73	66.3	70.3	76.2	73.6	70.5	69.8	....	....	69.5	69	79	72.5	....	....
10:30 A. M.	....	....	73.5	....	73.5	73	68.2	71	78	75	69.3	72.2	....	....	72.5	70.4	79	72.5	....	....
11:15 A. M.	74	73.5	80.5	71.0	73.3	73.3	72.7	72	80	76	75.2	74	....	....	74	71.7	80.5	73.4	....	....
1:00 P. M.	78	73.6	....	....	83	74	79.7	75.6	79	77	73.3	74.8	73	73.2	....	....	85	75.3	....	....
2:00 P. M.	78	73.3	....	....	81.6	74	76.2	76.5	78.6	76	73.4	75.3	75.5	74.5	....	....	79	75.1	....	....
3:00 P. M.	79	73.5	....	....	....	....	76.3	77	74.8	75.5	73	75	76	74.2	....	....	78.2	75.5	....	....
4:00 P. M.	78	73.5	....	....	79	74	76.6	76.5	72	74.3	73	74.1	74.2	73.6	....	....	74.1	74.5	....	....
5:00 P. M.	76	73.5	....	....	84	73.3	79	76.5	68.2	73.2	72	73	72.6	72.6	....	....	70.5	73.5	....	....
6:45-7:00 P. M.	71	71.6	....	....	71.5	73	71	74.1	65	71.1	68	71	62.6	71	....	....	63	69	....	....
9:00 P. M.	....	....	....	....	....	....	....	....	....	....	....	....	59	69	....	....	55	66.5	....	....
11:00 P. M.	....	....	....	....	....	....	....	....	....	....	....	....	55	68	....	....	50.5	66	....	....
Average	71	72	71.6	68.9	74.4	72.2	71 25	73.07	72.8	73.9	69.7	71.8	....	....	64.5	69.9	....	....	67.07	69.9

The prevailing winds in Bay county, as in the greater portion of the United States, are from the west and southwest, but they are modified in this region by the usual breezes from Saginaw bay. It was quite often noticeable that in the evening after the wind had been blowing from the west throughout the daytime, a breeze would spring up from the bay and continue to blow as long as the radiation from the land caused the heated air to rise. After an equilibrium had been established the breezes would die out again.

Mr. W. T. Shaw found in several places along the shore of Saginaw bay north of Kawkawlin, the meander posts of the Linear Survey at the water line, as near as it is possible to define this line in the swampy region which is generally characteristic of the west shore of the bay. It would thus seem that erosion has modified but very slightly the topography of the shore line of Bay county, since the time that survey was made.

3. *Elevation of Saginaw Bay and Lake Huron.*

By the levels of 1877 of the U. S. Lake Survey the high water mark of 1838 is given as 584.34 feet above the mean tidal elevation at Governor's Island in New York harbor. In the report of Huron county by Mr. Lane, and in this report, this determination has been used as the most accurate then available. More recent results, based on a more perfect determination by the U. S. Lake Survey, and levels of precision run by the U. S. Coast and Geodetic survey, increases the elevation of the high water mark of 1838 by .35 of a foot, making the elevation 584.69 feet A. T.

At Bay, and West Bay City, I have had some trouble in attempting to coordinate the results of different lines of leveling. The elevation of the zero of the government gage at the front Light House crib of the Saginaw river range is given as 580.25 feet A. T. This is the result of comparison

of 29 monthly means with corresponding ones at Harbor (Sand) Beach, Lake Huron. The U. S. Government also has a gage located on the Third or Midland Street bridge connecting Bay and West Bay City. The elevation of the zero of this gage is stated by the Engineers of the War Department as 583.75, but as we shall see, this is not within the limits of possibility. During the late summer of 1902 the light house keeper and I compared the gage elevation at the mouth of the river, and at the Third street bridge simultaneously on a quiet day, and found the zero to tally within less than 0.1 of a foot lower. It has been assumed, therefore, that the zero of both gages are approximately the same.

During the winter of 1902-3, Mr. E. L. Dunbar, Supt. of the Bay City Water Works, very accommodatingly ran a line of levels connecting the zero of the Third Street gage with the Bay City datum at the northwest corner of the water table of the Fraser House. The elevation of the local city datum is 50.00, and according to Mr. Dunbar, is 13.09 feet above the zero of the Third street bridge. This would make the elevation of the city datum 593.34 feet A. T. This elevation was used for all lines of levels connected with the Bay City bench mark. Mr. John H. Blomshield and R. R. McCloy of Bay City have also run levels connecting the zero of the Third street bridge with the city datum of Bay City and of West Bay City, which is based on the elevation of the former city. These levels tally within .007 of a foot, Mr. McCloy's levels being that much higher. Mr. McCloy is of the opinion that the amount of error in reading this gage, which is inconveniently situated, is not more than .05 of a foot. The result of these two surveys is to make the elevation of the Bay City datum 13.18 feet above the zero of the Third street bridge. As will be seen, this is .09 of a foot higher when compared with Mr. Dunbar's result. Mr. McCloy's levels were run for the survey August 30, 1902. The elevation of the West Bay City datum from the same survey would give a local elevation of 59.39 feet for the water table at the southwest corner of the Loose Block. This would be 602.82 feet above tide. Using this determination I have obtained the elevation of a line of levels which was run by Mr. Blomshield from the Loose Block along Henry street to Saginaw bay. This line would make the elevation of the bay, May 18, 1899, 579.99 feet A. T. The elevation of the Harbor beach gage for that month was 579.96 feet. The only accurate determination of the elevation of the gage at the Third street bridge is to connect it by a line of levels with the gage at the mouth of the river.

4. *Tilting of the Great Lake Basin.*

In Mr. Lane's report on Huron county[1] and in the "Michigan Miner" for June 1, 1900, there are references to this important determination by G. K. Gilbert of the U. S. Geological Survey. The result of Mr. Gilbert's investigation apparently shows that the land is rising to the northeast at a rate that would produce an apparent fall of the lake in Huron county of 0.2 foot per century. It is only intended here to bring together all local references which may be of use to future investigators.

Mr. E. L. Dunbar made the elevation of Saginaw river June 21, 1888, 39.481; March 23, 1888, 37.73; April 9, 1888, 37.65; of Saginaw bay on April 19, 1888, 37.974; April 21, 1888, 38.151; April 23, 1888, 38.037. These elevations are all in reference to the Bay City datum at the Fraser House, as defined above. We have already had occasion to refer to Mr.

[1] Geological Survey of Michigan, Vol. VII, part 2, p. 35.

Blomshield's elevation of Saginaw bay on May 18, 1899, when the height was 36.56 C. D. Additional data from the same authority are as follows: June 10, 1899, 36.77; Nov. 22, 1900, 36.025. This latest elevation was made with especial care for the Geological Survey on a still day. It is hardly necessary to add that these elevations of Mr. Blomshield are connected with the Bay City datum as determined by him and Mr. McCloy.

Assuming that the elevation above tide for the Bay City datum is 593.43, as determined by Blomshield and McCloy in August, 1902, it remains to be seen whether there has been any appreciable elevation of Bay City since Mr. Dunbar's determinations in 1886 and 1888. Inasmuch as Bay City is nearer the nodal line of stability than Harbor Beach, it is not to be expected that the amount of elevation could exceed .032 foot in the period from 1886 to 1902.

5. *Fluctuations of Mean Lake Level.*

These may be divided into three main classes. 1. Local fluctuations due to the direction of the winds, and variation in barometric pressure; 2, annual fluctuations and slight tidal elevations; and 3, variations in lake elevation of greater period which show the cumulative effects of rainfall of the previous years. These latter have been very instructively brought out in Plate V of the Huron county report.

The prevailing winds being from the southwest, with occasional storms from the northeast, the trend of Saginaw bay is peculiarly adapted to show results of the piling up or recession of the water. These results are enhanced by the shallowness of the bay, the depth with the exception of a local depression just south of the Big Charity Islands, gradually shelving off to a maximum depth of 9.5 fathoms or 57 feet.

In the survey chart of Saginaw bay issued by the U. S. Lake Survey, it is stated that during the prevalence of strong winds from the northward and northeast, the average increase of depth was observed to be seven inches and the maximum 15 inches. During the prevalence of strong winds from the southward and southwest the average decrease in the depth was by observation found to be two inches and the maximum eight inches. Along the same line, the observations of Mr. John H. Blomshield are worthy of record. During a storm from the northeast in the spring of 1899 the local elevation increased about 4.48 feet. On December 12, 1899, a strong south wind lowered the elevation of the bay 2.71 feet. The total amount of difference amounts to 7.19 feet. All these observations tend to show that the piling of the water due to the northerly or northeasterly winds is more pronounced. This is very likely due to the shore line at the southern extremity of the bay which produces a damming effect not obtainable in the main body of Lake Huron. The extreme amount of variation in elevation is perhaps not surprising. Wm. T. Blunt, U. S. Ass't. Engineer,[1] has shown that in a severe westerly gale, the west end of Lake Erie lowered the water from seven to eight feet. The reader is referred to that report for further details of this interesting subject.

Annual and periodic fluctuations in the elevation of Lake Huron are considerably elaborated by Mr. Lane in his Huron county report.[2] The subjoined table taken from the report of the U. S. Deep Waterways Commission, and brought up to date from records furnished the survey by Major W. L. Fisk of the U. S. Lake Survey, will suffice to give an accurate idea

[1] Report of the U. S. Deep Waterways Comm., 1896, p. 155.
[2] Volume VII, part 2, p. 37.

of the annual and periodic elevation of Saginaw bay and Lake Huron. In general the annual maximum of high water in June or July is due to the melting of the winter snows and spring rains. The lowest water is in the latest winter months, when the ground freezes and the rain changes to snow.

6. *Table Showing the Fluctuations in Lake Huron.*

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1819.....	.....	6.67	.....	.....	.....	4.67	.....	.....	....	.....	.....	.....	....
1828.....	.....	.....	.....	.....	.....	1.84	1.78	1.84	....	.....	.....	.....	....
1830.....	.....	.....	.....	.....	.....	1.84	.....	.....	....	.....	.....	.....	....
1836.....	.....	.....	4.00	.....	.....	1.00	.....	.....	....	.....	.....	.....	....
1837.....	.....	.....	.....	.....	3.20	0.59	.....	.....	....	.....	.....	.....	....
1838.....	.....	.....	.....	.....	.....	(0.00)	0.00	.....	....	.....	.....	.....	....
1839.....	.....	.....	.....	.....	.....	.....	1.33	.....	....	.....	.....	3.67	....
1840.....	4.50	.....	.....	3.07	2.96	2.88	2.62	(2.88)	3.23	3.38	3.56	3.79	....
1841.....	3.71	.....	.....	.....	.....	.....	.....	.....	....	.....	.....	4.43	....
1845.....	.....	.....	.....	.....	.....	3.50	.....	.....	....	.....	.....	.....	....
1846.....	(4.40)	4.42	4.27	3.79	3.43	3.44	(3.38)	3.65	4.13	4.38	4.66	5.03	4.08
1847.....	5.38	5.50	5.28	5.19	4.98	4.57	4.51	4.56	4.45	4.77	4.88	5.09	4.93
1848.....	5.29	5.34	c 5.35	5.00	5.30	5.05	4.47	4.46	4.64	4.72	4.82	4.77	4.93
1849.....	4.80	4.70	4.90	(4.70)	(4.60)	(4.05)	(3.75)	3.75	....	.....	.....	.....	....
1851.....	.....	.....	.....	.....	.....	.....	2.57	2.30	....	.....	b2.43	.....	....
1852.....	.....	.....	.....	.....	.....	.....	.....	1.50	2.02	2.10	1.96	.....	....
1854.....	.....	.....	.....	3.70	3.05	(2.78)	(2.46)	(2.50)	2.61	3.18	3.45	3.53	....
1855.....	3.79	(3.82)	3.75	3.67	3.10	2.77	2.68	2.57	2.48	2.61	2.81	2.71	3.06
1856.....	2.65	3.14	3.12	2.99	2.56	2.63	2.56	2.75	2.87	3.06	3.12	3.35	2.90
1857.....	3.55	3.27	(3.14)	2.68	2.33	2.03	1.60	1.41	1.56	1.49	2.30	2.26	2.30
1858.....	2.33	2.62	2.70	2.18	1.70	1.28	0.89	0.93	1.33	1.48	(1.81)	1.79	1.75
1859.....	2.28	2.15	2.09	1.45	1.30	1.30	0.65	0.95	1.19	1.52	2.02	1.95	1.57
1860.....	2.02	2.07	1.93	1.96	1.91	1.67	1.58	1.66	1.85	2.23	2.35	2.65	1.99
1861.....	2.86	2.82	2.68	2.48	1.86	1.52	1.40	1.29	1.37	1.59	1.90	2.03	1.98
1862.....	2.41	2.42	2.51	2.30	1.93	1.81	1.76	1.78	2.00	1.72	2.04	2.33	2.08
1863.....	2.49	2.64	2.69	2.62	2.30	2.17	2.26	2.25	2.39	2.65	2.69	2.92	2.51
1864.....	3.06	3.10	3.10	2.90	2.47	2.46	2.51	2.62	2.94	(3.47)	(3.64)	(3.77)	3.00
1865.....	4.13	4.04	3.87	3.38	3.22	3.18	2.75	2.73	2.85	3.09	3.65	3.96	3.40
1866.....	4.22	4.46	4.41	3.96	3.78	3.49	3.23	3.17	3.32	3.43	3.52	3.78	3.73
1867.....	3.80	3.75	3.57	3.28	3.06	2.75	2.60	2.67	2.94	3.27	3.73	4.08	3.29
1868.....	4.24	4.28	3.60	3.70	3.42	3.21	3.18	3.52	3.76	3.99	4.06	4.34	3.78
1869.....	4.44	4.37	4.63	4.26	3.93	3.40	3.02	2.76	2.87	3.23	3.35	3.63	3.66
1870.....	3.57	3.48	3.18	2.76	2.42	2.28	2.17	2.26	2.12	2.52	2.92	3.27	2.75
1871.....	(2.83)	(2.91)	(2.31)	(2.11)	(1.76)	(1.72)	(1.69)	2.29	2.61	3.11	3.32	3.69	2.53
1872.....	3.86	4.06	(4.17)	4.14	3.74	3.34	3.24	3.27	3.37	3.49	3.79	4.08	3.71
1873.....	4.25	4.28	4.21	3.80	3.30	2.90	2.70	2.69	2.86	2.89	2.99	3.15	3.34
1874.....	3.13	2.99	2.85	3.00	2.95	2.61	2.45	2.56	2.72	2.96	3.23	3.48	2.91
1875.....	3.69	3.75	3.71	3.52	3.17	2.86	2.67	2.70	2.66	2.85	2.96	3.23	3.15
1876.....	3.11	3.13	3.00	2.72	2.12	1.63	1.19	1.25	1.36	1.76	1.91	2.10	2.11
1877.....	2.39	2.40	2.47	2.39	2.22	2.26	2.08	2.18	2.45	2.59	2.64	2.69	2.40

Table Showing the Fluctuation in Lake Huron.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1878.....	2.79	2.96	2.79	2.86	2.46	2.29	2.25	2.35	2.64	2.63	2.82	3.02	2.66
1879.....	3.32	3.56	3.60	3.57	3.44	3.30	3.26	3.39	3.47	3.71	3.83	3.85	3.53
1880.....	3.80	3.86	3.87	3.86	3.46	2.97	2.66	2.77	2.88	3.24	3.36	3.56	3.36
1881.....	3.69	3.30	3.29	3.27	2.95	2.78	2.63	2.80	2.96	2.71	2.58	2.75	2.98
1882.....	2.90	3.13	2.99	2.77	2.60	2.37	2.23	2.17	2.29	2.52	2.77	2.92	2.64
1883.....	3.12	3.17	3.13	3.12	2.55	2.13	1.65	1.45	1.77	2.10	1.99	2.10	2.36
1884.....	2.29	2.44	2.40	2.09	1.87	1.81	1.73	1.85	2.20	2.04	2.39	2.65	2.15
1885.....	2.38	2.47	2.47	2.36	1.96	1.67	1.61	1.46	1.56	1.79	1.98	2.18	1.99
1886.....	2.18	2.11	1.92	1.63	1.30	1.21	1.37	1.52	1.70	1.83	2.10	2.42	1.77
1887.....	2.59	2.40	2.19	2.28	2.08	1.96	1.88	2.09	2.44	2.66	3.11	3.40	2.42
1888.....	3.51	3.60	3.43	3.29	2.85	2.55	2.52	2.48	2.78	3.07	3.25	3.46	3.07
1889.....	3.60	3.68	3.78	3.77	3.63	3.30	3.04	3.10	3.27	3.64	3.98	4.14	3.57
1890.....	4.07	4.19	4.21	4.07	3.76	3.33	3.14	3.14	3.41	3.62	3.82	4.12	3.74
1891.....	4.32	4.43	4.46	4.13	3.89	3.94	3.91	4.01	4.21	4.57	4.88	4.94	4.31
1892.....	4.92	4.98	4.92	4.84	4.71	4.18	3.89	3.81	3.98	4.19	4.52	4.76	4.48
1893.....	5.01	5.06	4.98	4.60	3.97	3.22	3.50	3.64	3.93	4.14	4.37	4.57	4.25
1894.....	4.62	4.61	4.46	4.23	3.83	3.53	3.38	3.65	3.84	4.08	4.27	4.57	4.09
1895.....	4.82	4.94	4.93	4.83	4.66	4.59	4.62	4.71	4.84	5.13	5.52	5.76	4.95
1896.....	5.69	5.57	5.67	5.64	5.24	4.87	4.81	4.77	4.95	5.15	5.29	5.41	5.25
1897.....	5.33	5.42	5.28	4.94	4.37	4.15	3.95	3.94	4.20	4.55	4.67	4.97	4.65
1898.....	5.12	5.06	4.83	4.34	4.22	4.06	3.96	4.07	4.26	4.57	4.65	4.84	4.50
1899.....	5.10	5.24	5.09	4.92	4.38	3.99	3.70	3.79	3.99	4.40	4.54	4.73	4.49
1900.....	4.96	4.95	4.92	4.80	4.65	4.48	4.23	4.14	4.06	4.12	4.12	4.32	4.48
1901.....	4.56	4.70	4.71	4.24	4.03	3.93	3.75	3.68	3.96	4.17	4.41	4.74	4.24
1902.....	4.83	5.03	5.12	4.89	4.68	4.29	4.06	4.02	4.27	4.58	4.66	4.89	4.61
1903.....	5.11	5.07	4.93	4.58	4.46	4.29	4.10	4.12	4.05	4.02	4.44	4.73	4.49
1904.....	4.78	4.78	4.61	3.06	3.74	3.27	3.14	3.16	3.33	3.43	3.74	4.19	3.77
Mean....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1860-1903	4.27	4.31	4.24	4.02	3.71	3.47	3.31	3.34	3.50	3.72	3.91	4.14	3.86

Remarks. The elevation for February, 1819, is shown from the Michigan Geological report; for June, 1819, 1828, 1830, 1836, 1837; the years 1839, 1840, and January, 1841, from an article by Chas. Whittlesey, Michigan Geological Report for 1839, and table by Mr. A. W. Higgins. During the years 1860–1864 inclusive, the readings are from the Point Aux Barques, Michigan, gage; from 1865-1870 at Milwaukee, Wisconsin; from 1871-1874, inclusive, at Port Austin, Michigan; from 1875-1903 at the Harbor Beach gage. The interpolated monthly means are indicated by parentheses, and are found for any year by taking the corresponding monthly means at Wisconsin and correcting the same by the average difference between the observed monthly means at Point Aux Barques or Port Austin for that year and the corresponding observed monthly means at Milwaukee, Wisconsin. The readings given above are below the high water of 1838 or the Lake Survey plane of reference. The elevation equal 584.34 feet above sea level. As we have already observed a more accurate determination of this high water mark of 1838 is 584.69 feet A. T. The Sanitary canal at Chicago opened 17th January, 1900. Average discharge January, 1901, 250,000 cubic feet per minute.

During dredging operations of the U. S. Engineers at the mouth of the Saginaw river, the following record of gage readings were taken by the inspectors.

Saginaw River, Michigan. Record of gage readings during dredging operations of the U. S. Engineers.

Years.	Months.	Dates.	Monthly means.	Elevation of mean water level for the month.
1884	October	15–31	*1.63	581.88
1884	November	1–25	*1.74	581.99
1885	May	1–31	*2.26	582.51
1885	June	1–30	*2.51	582.76
1885	July	1–31	*2–51	582.76
1885	August	1–31	*2.68	582.93
1887	August	1–28	*2.21	582.46
1887	September	1–30	*1.77	582.02
1889	May	17–31	*1.10	582.35
1889	June	1–30	*0.99	581.24
1889	July	1–31	*0.99	581.24
1889	August	1–9	*0.97	581.22
1891	May	15–30	*0.21	580.46
1891	June	1–30	*0.26	580.51
1891	July	1–31	*0.15	580.40
1891	August	1–31	*0.01	580.26
1891	September	1–30	–0.23	580.02
1891	October	1–31	–0.57	579.68
1891	November	1–20	–0.86	579.39
1892	May	6–31	–0.52	579.73
1892	June	1–30	–0.08	580.17
1892	July	1–21	*0.03	580.28
1892	October	3–31	–0.38	580.63
1892	November	1–23	–0.48	579.77
1895	May	6–31	–0.54	579.71
1895	June	1–28	–0.54	579.71
1895	July	5–29	–0.56	579.69
1895	August	1–30	–0.71	579.54
1895	September	3–28	–0.93	579.32
1895	October	1–31	–1.31	578.94
1895	November	1–29	–1.51	578.74
1896	April	21–30	–1.54	578.71
1896	May	1–28	–1.17	579.08
1896	June	1–30	–0.75	579.50
1896	July	1–11	–0.68	579.57
1899	September	11–30	*0.07	580.32
1899	October	2–31	–0.36	579.89
1899	November	1–30	–0.39	579.86
1900	May	15–31	–0.48	579.77
1900	June	1–30	–0.46	579.79
1900	July	1–24	–0.37	579.88

REMARKS.

The monthly means are computed from tri-daily readings taken by the inspectors while the dredging operations were in progress at the mouth of the Saginaw river.

The gage is located on the channel face of the front L. H. crib of the Saginaw River range, and its zero is 8.525 feet below the top of this crib.

The elevation of the zero of this gage, from comparison of 29 monthly means with corresponding ones at Sand Beach Harbor, Lake Huron, is 580.25 feet above mean tide at New York.

From comparison of May, June and July, 1889, September, 1887, and May, June, July and August, 1885, with the Milwaukee gage, we find the elevation to be (584.38-4.13625)=580.24 A. T.

7. *Explanation of Contour Map.*

In the descriptive portion of the topography which pertains to this chapter, the elevations are given above tide. By this is meant the elevation above the mean tidal height at Governor's Island in New York bay. This is the zero or base which has been adopted by the U. S. Government, and all topographic elevations are stated as so many feet or fractional parts of a foot above this datum or zero. In the contour lines which are represented on the map forming part of this report, each line is intended to represent

the same constant elevation above sea level, or above tide as it is usually stated. This is generally abbreviated A. T. In this connection, as to the proper significance of contours, we may quote from the Huron county report.[1] "As we have said, in 1896, Lake Huron had been retreating. Imagine the process suddenly reversed, and the lake raised 10 feet and the new shore line marked upon the map. Suppose the lake raised 10 feet more, and the resulting shore line marked upon the map of the county. Such lines would be called contour lines, and all points of a given contour line are obviously at the same level above the lake." In the map presented in this report the contour lines are represented at intervals of approximately five feet of vertical elevation. In the lowest contour line adjacent to Saginaw bay, it will be observed that the line is marked 585. This means that if Saginaw bay were to rise 5.4 feet from its elevation of 579.61 A. T. in December, 1903, that the shore line of the lake would wash the plain and sand ridges and form inlets up the valleys as indicated by this 585 foot line. The same would be true of each successive line of greater elevation. In the different intervals, islands would occasionally appear. These imaginary islands are represented by contour lines which entirely enclose a certain amount of land. Such an area will be observed in the southwestern part of Williams township, where the 650 foot contour line encloses a sand ridge. It will be readily observed that there is a great advantage in having a common base as a reference plane from which to estimate all points of elevation, and in this report it may be understood that the mean tidal elevation of New York bay furnishes such a base. In the chapter on coal the same base was used to obtain the elevation of the different coal seams, from which the correlations were worked out. The contours are based on 121 drain lines, 41 lines of roads and water works lines of levels, and all the railroad profiles in the county, with the exception of two lines extending north and south of Mt. Forest. This information was supplemented by a large number of aneroid elevations which were checked from base lines and barograph sheets. With the road and drain levels, the elevation of all the stations of each line were obtained above sea level, and every five feet of elevation plotted as accurately as possible on the contour map.

In the remarks made above we only had reference to vertical elevations. It is also obvious that in order to produce an accurate contour map, the horizontal position of topographic features must be taken into account. In Bay county the old beach lines of the former lake system, intermittent and constant water courses, together with two or three slightly developed morainal systems, are the only pronounced surface features which should be taken into account, excepting certain swamp areas, which were more or less accurately delineated by the Linear Survey. The beach lines of any importance were meandered, the compass lines being checked up from section and quarter corners. The course of the Saginaw river was meandered by the Linear Survey, and at a later date the lower reaches were accurately located by the U. S. Lake Survey. The course of the Kawkawlin river and its two forks was only obtained by the Linear Survey at the intersection of the section lines. In the interior of sections we have obtained a number of checks on this river from drain and beach meanders. The location of most of the intermittent streams in the lower half of the county is from drain meanders. Farther north, Mr. Shaw and I obtained a large amount of additional information in the course of the township surveys. Aside from the

[1] Michigan Geological Survey, Volume VII, part 2, p. 42.

topographic features, the greater part of Bay county may be said to be a plain gently sloping towards Saginaw bay and Saginaw river. An exception to this is found in the moraine, which trends through the western part of Gibson township, which produces a fairly well marked line of range hills in the northwestern part of the township. These hills face the west, the descent on the side away from the ice being much more pronounced than where the material was deposited underneath and immediately in front of the retreating glacier. Taking into account all the factors which enter into the preparation of a contour map, and the comparative simplicity of the topography, it is believed that the map here presented is sufficiently accurate and detailed to serve the purposes of drainage, engineering, and general scientific research.

The streams of Bay county are either estuaries of the bay, or intermittent during a portion of the year. Such an estuary stream is the Saginaw river, which occasionally flows north or south according to the direction and velocity of the wind in altering the elevation of its outlet into the bay. It was noted in the chapter on coal that the middle and perhaps upper reaches of the water course in Bay county, occupied a line of reversed preglacial drainage. There seems to have been considerable uniformity in the amount of drift deposited in the lower portion of Bay county, which may account for the depression in which the river is located here. Whether the Saginaw has at one time deposited a delta at its mouth is not certain. The topography of the bay shore east of the outlet, and as far as the inlet on the range line 5 and 6 E., rather indicates such a lateral delta. In this supposition the inlet above mentioned would be the former outlet of the river. Mr. John H. Blomshield prepared in 1894, a map showing the original meander line and the present course of the river. This would indicate that the river has cut into its east or right bank since the Linear Survey. The general swing of the river east northeast, below its outlet, would favor such a modification.

8. *Kawkawlin River and the South Fork.*

In the present stage of low water elevation, the Kawkawlin river is an estuary of the bay above Henry street. At Kawkawlin village Mr. Blomshield made the elevation of the water surface 581.15 A. T., at the bridge in the west part of town. At the outlet of Culver creek in section 16 of Monitor township, the elevation of the lower fork has increased to 584.5 feet A. T. On the township line between Williams and Monitor, the elevation of two drain lines which empty near each other there is 596 feet A. T. It will be observed that the fall from the town line to the mouth of Culver creek is approximately four feet to the mile, and from there only four feet to the outlet of the river a distance twice as great. This fall is where the stream is deflected by the Monitor moraine. The south fork is also characteristic of the river topography of the Saginaw valley, in that it makes a large bend to the south before finding an outlet. In this measure it is to be compared to the Tittabawassee which swings south around a moraine before emptying into the Saginaw. While the moraine which produces the elevation and deflection of this stream in Bay county is not well marked, the result is, as we have seen, the "willowy" drainage characteristic of the river topography in this region. Where the south fork is crossed by the Garfield road in Beaver township, at the northeast corner of Sec. 27, T. 15 N., R. 3 E,. the elevation is 604.65 feet A. T. North of Duel P. O., and on the east line of section 7 the stream is 635 feet A. T. The stream valley

here is in places quite shallow, the bed in some places changing its channel from season to season. North and south of the outlet of Skelton creek, in Williams township, the stream course for over a mile is north and south. This is probably due to the location of the moraine in Monitor township to the eastward. There are indications that this stream existed contemporaneously with the Pleistocene lakes, the stream advancing as the lake receded, *pari passu*. At the time that the Algonquin beach was being formed, this fork probably emptied into lake Algonquin near the present township line of Monitor and Williams. On the south side of the stream course there, the drainage has no outlet directly into the river. I have taken this dam to be an old flood plain. The elevation there is nearly 600 feet A. T.

The Lower fork of the Kawkawlin, in common with the Tittabawassee, receives a much larger number of tributaries from the south and west than from the north. In fact there is scarcely any drainage stream which comes in from the north worthy of mention. From the south there are six water courses flowing northeast and east which serve as valuable drainage outlets in Monitor, Williams and Beaver townships. Going up stream these are known as Culver, Hopler, Perry, Skelton, Willard and Davis creeks. This drainage result is probably due to the more even and extended deposition on the back and bottom of the moraine last deserted, which as we have seen in Gibson township, is more abrupt in front. In Williams the crest of this moraine trends northwest, in the southwestern part of the township. Farther south it passes north and east of Freeland in Saginaw county. Mr. F. B. Taylor correlates this moraine with the one we have observed in the western part of Gibson. If this is true it is not very well marked east of Midland or Estey. The crest of this formation is the divide between the Tittabawassee river on the west, and the Kawkawlin and other drainage courses directly tributary to the bay, to the east. The amount of rainfall which goes into the Tittabawassee from Bay county is a negligible quantity.

9. *The North Fork of the Kawkawlin River.*

The north fork of the Kawkawlin passes through Kawkawlin, Beaver and Garfield townships. North of Bedell's corners the water level is 593.3 A. T., on the Garfield road near the northeast corner of section 10 in Beaver, the height has increased to 613.3 feet A. T.; at the north quarter post of section 18 in Garfield, Mr. John H. Blomshield made the elevation 637.74 A. T. It will thus be seen that the project to make a dredge cut out of this stream is scarcely feasible. In the western portion of Garfield township this water course occupies a well marked valley which is much too large for the present stream course. This valley way is probably the result of morainal inequalities of deposition. The antiquity may be inferred from the beach lines which occasionally flank both sides of the stream, being deposited when the lake formerly extended as an inlet up what is now the valley. It has therefore been assumed that the valley was formed previous to its occupancy by this stream, the stream being consequent and not formative. Throughout its course in the northern part of Beaver and the northwestern part of Kawkawlin township, this stream generally occupied a large and relatively deep valley which evidently owes its origin to a different agency than the present stream. Inasmuch as this region was covered with water at the time of the glacial retreat, its origin can scarcely be ascribed to ice drainage. Above its outlet, in the eastern part of Kawkawlin township, the stream has rather a rapid fall to the south, the course of the stream

probably being determined by the same low, ill defined moraine, which we had occasion to notice in connection with the south fork in Monitor township.

During the period when lumbering was an important occupation in Bay county, the persons engaged in that occupation, located what are known locally as bayous in this fork of the river, in the eastern and central portion of Kawkawlin township. The O'Neil bayou situated in section 27 is about one-half mile long, and is said to be from 12 to 14 feet deep. At its upper extremity there is a sandbar called Joe Duponts neck on the east and west quarter line of section 27. Next above this is the Silvernail bayou extending from the south 80-rod line of section 22, and up stream for over a quarter of a mile west of the town hall. The depth is not far from eight feet. The Allen bayou, next going up stream, begins 40 rods south of the sawmill in the northwest quarter of section 21, and runs north 100 rods. The depth varies from six to eight feet. The White bayou is in the southeast quarter of section 17. These so-called bayous are not so in the proper sense of the word, being only deep pools of water in the present stream course, and not semi-isolated channels. In the south, bayous are commonly formed by the cutting of ox bows, leaving the stream to pursue, at least for the time being, a more direct course. The notes concerning the Kawkawlin river bayous were given me by several men formerly engaged in lumbering along this fork. They have also come under the observation of G. M. Bradford, a botanical student of Bay county, and J. H. Tryon of the Agricultural College.

10. *Drainage in Northern Bay County.*

The drainage in the remaining portion of Bay county is of the simplest and most natural character, the stream courses following slight surface inequalities due to inequalities of morainal formation along a smooth tilted plain. Occasionally these swales are flanked by low sandy elevations, which occasionally rise into beach lines. The principal drainage courses such as Michie creek, Chute creek, Pinconning creek, White Feather creek, and the different feeders of the Saganing and Pine river in Mt. Forest and Gibson townships, extend over three-quarters of the way across Bay county east and west. They pursue independent and nearly parallel lines of drainage. In future drainage operations they could very well be cleaned out, straightened and deepened so as to serve in reclaiming considerable areas of fertile land. If they are made to serve as drain trunk lines the size should considerably exceed that of drains which only tap relatively limited areas.

11. *Bay County Drains.*

With the exception of drains actually meandered or levelled, the areas tributary to the different drains have in general not been given. Such areas can be determined from the contour map. In all other cases where we were able to obtain the location and elevation of drain courses, the area tributary to that drain will be found printed with the location in the latter portion of this chapter. These drains have been arranged in alphabetic order and numbered from 1 to 121, there being that many lines of levels. On the contour map these numbers have been used instead of the names of the different drains. In many cases, as in the levels of Hopler and Skelton creeks in Williams township, the drains have not been dug. The levels, however, even if not directly available, will serve to show the

utility of intermittent water courses, and other lines, for drainage purposes. With the numerous other lines of levels the information can be probably used in cleaning out, the depth being made the same as in the original survey, if it is not found advisable to go deeper. The elevations of all drain lines have been obtained above sea level (A. T.), either from the elevation of Saginaw bay, from road and railroad profiles, or lines of levels especially run by J. H. Blomshield for this purpose. By having each line conform to a definite base, such work is rendered more systematic, and the work of determining drainage areas made more equitable. In future surveys it will probably be found useful to connect lines of levels with the levels and elevations given in this report.

For additional information concerning drain construction and engineering, the reader is referred to a publication entitled "The Drainage of Fens and Low Lands," by W. H. Wheeler.

12. *Tables of Elevations.*

Primarily all of these elevations are based on the table of fluctuations of Lake Huron. The elevations here presented were obtained from railroad profiles and from the County Commission. In all cases the elevation is stated above tide, together with the local elevation from which this was generally determined.

Michigan Central R. R. Jackson, Lansing & Saginaw Division.

	A. T.
Saginaw-Bay county line	584
Brooks	587
Center street, West Bay City	598
West Bay City	587
Henry street, West Bay City	597
Kawkawlin	599
Linwood	589
State Road (Michie P. O.)	602
Pinconning	600
White Feather	604
Bay—Arenac county line	618

Michigan Central R. R. Detroit & Bay City Division.

Reese	628
Arn	597
Quanicassee State Drain	595.34
Mungers	596
Bay City	592

Michigan Central R. R. Midland Division.

Monitor station	600
Auburn	617
Fisherville	639
Colden on Bay—Midland county line	659

Michigan Central R. R. Saginaw Bay & Northwestern Division.

Pinconning, J., L. & S. crossing	594
Beardsleys	618
Woodville	627
Nine Mile	656
Mt. Forest	690

Elevations of post offices in Bay county determined with spirit level.

Bedell, Michigan Geological Survey	599
Bently, Michigan Geological Survey	737
Crump, Bay County Stone Roads Commission	633
Cummings, Bay County Drain Commission	620
Garfield, P. O., Michigan Geological Survey	626
North Williams, Bay County Stone Roads Commission	614

In the railroad elevations given above the point taken is the base of the rail in front of the depot, excepting for the Midland division, where the elevation is the surface of the ground at the depot or siding.

13. *Bay County Drains and Drainage Areas.*[1]

1. Alarie drain. Outlet Saginaw Bay on the N. line of Sec. 18, T. 16 N., R. 5 E Drainage area, the N. E. ¼ of the N. E. ¼, the N. W. ¼ of the N. E. ¼, the N. ½ of the N. E. ¼ of the N. W. ¼ and the N. ½ of the N. W. ¼ of the N. W. ¼, Sec. 13, T. 16 N., R. 4 E. The N. ½ of the N. ½ of the N. E. ¼ of Sec. 14, T. 16 N., R. 4 E. and the S. ½ of the S. ½ of the S. E. ¼, Sec. 11, T. 16 N., R. 4 E. Total length 494 rods. Amount of fall 13 feet.

2. Allison drain. Outlet into the Russell drain at the N. E. corner of Sec. 15, T. 13 N., R. 6 E. Drainage area, the E. ½ of the E. ½ of Sec. 15, and the W. ½ of the W. ½ of Sec. 14, T. 13 N., R. 6 E. Length one mile.

3. Aspin drain. Outlet Hopler creek, in the S. W. ¼ of the N. W. ¼, of Sec. 16, T. 14 N., R. 3 E. Drainage area, E. ½ of S. E. ¼ of Sec. 17 and E. ½ of the N. E. ¼, Sec. 20, T. 14 N., R. 3 E.

4. Bancle drain Outlet of drain Saginaw Bay, on the N. line of Sec. 12, Kawkawlin. township, T. 15 N., R. 4 E. Drainage area, the south ½ of the S. ½ of Sec. 1 (fractional), area 46 acres, and the N. ½ of the N. fractional half of Sec, 12, T. 15 N., R. 4 E., the N. E. ¼ of Sec. 11, and the S. ½ of the S. E. ¼ of Sec. 2, T. 15 N., R. 4 E.

5. Bangor and Monitor State drain. Outlet of drain Kawkawlin river near the W. ¼ post of Sec. 1, T. 14 N., R. 3 E. Drainage area N. W. ¼ of the S. W. ¼ of Sec. 1, and the N. E. ¼ of the S. W. ¼, Sec. 1, the S. E. ¼ of the S. W. ¼ of Sec. 1, T. 14 N., R. 4 E.; also in Sec. 12, T. 14 N., R. 4 E., the N. E. ¼ of the N. W. ¼ and the N. W. ¼ of the N. E. ¼, the S. E. ¼ of the N. W. ¼, the S. ½ of the N. E. ¼, and the N. ½ of the S. E. ¼, Sec. 12, T. 14 N., R. 4 E. In Bangor township, T. 14 N., R. 5 E., the S. ½ of the N. W. ¼ and the N. ½ of the S. W. ¼, Sec. 7, also the S. ½ of the S. W. ¼ and the S. ½ of the S. E. ¼ of Sec. 7. In Sec. 18, the E. ½, of the N. W. ¼, and the N. E. ¼ of Sec. 18, also the S. E. ¼ of Sec. 18, and the E. ½ of the S. W. ¼ of Sec. 18, T. 14 N., R. 5 E. In Sec. 19 the N. W. ¼ of the N. E. ¼ and the N. E. ¼ of the N. W. ¼.

6. Baxman drain. Outlet of drain, into the Squaconning creek, on the W. line of Sec. 6, T. 13 N., R. 5 E. Drainage area in Sec. 24, Monitor township, T. 14 N., R. 4 E., the E. ½ of the S. E. ¼. In Sec. 19, T. 14 N., R. 5 E., the W. ½ of the S. W. ¼. In Sec. 25, T. 14 N., R. 4 E., the E. ½ of the N. E. ¼, and the S. W. ¼ of the N. E. ¼, also the S. E. ¼ of Sec. 25, T. 14 N., R. 4 E. In Sec. 30, T. 14 N., R. 5 E., the W. ½ of the N. W. ¼ and the W. ½ of the S. W. ¼. In Sec. 36, E. ½ of the E. ½, T. 14 N., R. 4 E. and the W. ½ of the W. ½ of Sec. 31, T. 14 N., R. 5 E. In Sec. 1, Frankenlust township, T. 13 N., R. 4 E., the N. E. ¼ of the N. E. ¼ of the N. E. ¼ and in Sec. 6, Frankenlust township, T. 13 N., R. 5 E., the N. W. ¼ of the N. W. ¼ of Sec. 6.

7. Beard drain. Outlet into the Quanicassee and Cheboyganing State drain on the E. and W. ¼ line of Sec. 23 and about 80 rods west of the center of the Sec. This drain

[1] Elevations and locations of the different Bay County drains on file in the office of the State Geologist and the Bay County Drain Commissioner.

is entirely in T. 13 N., R. 6 E. Drainage area, the W. ½ of the S. W. ¼, of the N. W. ¼ of Sec. 23, and in Sec. 23, the N. W. ¼ of the N. W. ¼ of the S. W. ¼. In Sec. 22, the S. ½ of the N. E. ¼ and the N. ½ of the N. E. ¼ of the S. E. ¼, also the N. W. ¼ of the S. E. ¼, Sec. 22, the S. ½ of the N. W. ¼ and the N. ½ of the S. W. ¼, Sec. 22. The S. ½ of the N. E. ¼ and the N. ½ of the S. E. ¼ Sec. 21. The S. E. ¼ of the N. W. ¼ and the N. E. ¼ of the S. W. ¼, the E. ½ of the S. W. ¼ of the N. W. ¼, the E ½ of the N. W. ¼ of the S. W. ¼, the N. W. ¼ of the N. W. ¼ of the S. W. ¼, the S. W. ¼ of the S. W. ¼ of the N. W. ¼, all in Sec. 21.

8. Behmlander drain. The north outlet of this drain is into the Kawkawlin river, in the S. E. ¼ of Sec. 2, Monitor township, T. 14 N., R. 4 E. The south outlet is in Sec.1, Frankenlust township, T. 13 N., R. 4 E., where it empties into an estuary of Squaconning creek. Drainage area, in Sec. 1, T. 13 N., R. 4 E., is approximately the N. E. ¼ of the N. W. ¼. The following drainage areas is included in T. 14 N., R. 4 E. In Sec. 36 the S. W. ¼, in Sec. 35, the E. ½ of the S. E. ¼. The N. E. ¼ of Sec. 35, and the W. ½ of the N. W. ¼ of Sec. 36, also in Sec. 35, the N. ½ of the N. W. ¼ and the S. ½ of the S. W. ¼ of Sec. 26. The drainage here is cut up by an old beach line. In Sec. 34, the N. E. ¼ of the N. E. ¼. In Sec. 27, the E. ½, in Sec. 26, the W. ½ of the S. W. ¼ and the W. ½ of the N. W. ¼, in Sec. 22, the E. ½ of the S. E. ¼ and the W. ½ of the S. W. ¼ of Sec. 23, also the E. ½ of the N. E. ¼ of Sec. 22 and the W. ½ of the N. W. ¼ of Sec. 23, in Sec. 15, the S. E. ¼ of the S. E. ¼, in Sec. 14, the W. ½, and the N. W. ¼ of the N. E. ¼, in Sec. 11, the S. W. ¼, and the E. ½ of the S. E ¼ of Sec. 10, also in Sec. 11, the N. W. ¼ and the N. W. ¼ of the N. E ¼ of the same section, also the S. ½ of that part of Sec. 2, of the S. E. ¼ which lies south of the Kawkawlin river. Levels by J. Madison Johnston.

9 Bennett drain. This drain empties into the Bublitz drain at the S. E. cor. of Sec. 14, T. 13 N., R. 6 E. In Sec. 23, T. 13 N., R. 3 E., the drainage area is , E. ½ of the N. E. ¼, and in Sec. 24, same township and range, the W. ½ of the N. W. ¼, the E ½ of the S. E. ¼ of Sec. 23, and the N. ½ of the S. W. ¼ of Sec. 24, the S. W. ¼ of the S. W. ¼, also in Sec. 24.

10. Betzold drain. The outlet of this drain is in a swale in the N. W. ¼ of the N. W. ¼ of Sec. 36, Beaver township, T. 15 N., R. 3 E. The drainage area is the W. ½ of the S. E. ¼ of Sec. 23, and the E. ½ of the S. W. ¼, of Sec. 23, the N. ½ of the N. E. ¼, and the S. ½ of the N. E. ¼ of Sec. 26, and the N. ½ of the S. E. ¼ and the S. E. ¼ of the S. E. ¼ of Sec. 26. Also in Sec. 25, the S. W. ¼ of the S. W. ¼. In Sec. 35, the N. E. ¼ of the N. E. ¼, and in Sec. 36, the N. W. ¼ of the N. W. ¼. This drain is all in T. 15 N., R. 3 E.

11. Birch Road drain. Outlet of drain is into the Young drain at the N. E. corner of Sec. 36, Portsmouth township, T. 14 N., R. 5 E. The drainage area in Sec. 36, is the E. ½ of the E. ½ while in Sec. 31, T. 14 N., R. 6 E., it is the west half of the N. W. ¼, also in Sec. 31, the W. fractional ½ of the S. W. ¼. In Sec. 1, T. 13 N., R. 5 E., there is the E. ½ of the N. E. ¼ of the N. E. ¼ and the S. E. ¼ of the N. E. ¼. In Sec. 6, T. 13 N., R. 6 E., there is the W. ½ of the W. ½ of the N. W. ¼ and the E. ½ of the S. W. ¼ of the N. W. ¼, Sec. 6, also in the same section, the N. W. ¼ of the S. W. ¼. In Sec. 1, T. 13 N., R. 5 E., the N. E. ¼ of the S. E. ¼.

11A. Bowkowtonden drain. Outlet of drain in the Kawkawlin river on the north line of Sec. 2, Monitor township, T. 14 N., R. 4 E. The following drainage areas are included in the above township and range. In the Bowkowtonden reserve, the N. ½ of the N. ½ of that part lying north of the quarter line road of Secs. 3 and 2. Also in the N. ½ of the N. W. ¼, of Sec. 3. In Sec. 4, the N. ½ of the N. E. ¼ and the N. ½ of the N. W. ¼. In Sec. 5, the N. ½ of the N. ½, in sec. 6, the N. ½ of the N. ½. In Kawkawlin township, T. 15 N., R. 4 E., are the following drainage areas. In Sec. 35, that part of the S. W. ¼ lying west of the river, and the south 80 rod line. In Sec. 34, the S. ½ of the S. ½, in Sec. 33, the S. ½ of the S. ½, and the S. ½ of the S. ½ of Sec. 32, and the S. ½ of the S. ½ of Sec. 31.

12. Bradford Creek drain. The outlet of this drain is into the south fork of the Kawkawlin river, just west of the Sec. line between 16 and 17, T. 14 N., R. 4 E. The following drainage areas are in the same township and range, the S. E. ¼ of Sec. 17, the N. W. ¼ of the N. E. ¼ of Sec. 20, the S. E. ¼ of the S. W. ¼ of Sec. 17, the N. W. ¼ of Sec. 20, the E. ½ of the N. E. ¼ of Sec. 19, the N. E. ¼ of the S. E. ¼ of Sec. 19, the S. W. ¼ of the N. E. ¼ of Sec. 19, the W. ½ of the S. E. ¼, Sec. 19, the E. ½ of the S. W. ¼ of 19, the N. ½ of the N. W. ¼ of Sec. 30. In Williams township, T. 14 N., R. 3 E., the following lands are drained, the N. E. ¼ of Sec. 25, the N. W. ¼ of the S. E. ¼, Sec. 25, the E. ½ of the S. W. ¼ of Sec. 25, the S. W. ¼ of the S. W. ¼ of Sec. 25. In Sec. 26, the S. ½ of the S. ½ of the S. E. ¼, in Sec. 35, the N. E. ¼ of the N. E. ¼, the W. ½ of the N. E. ¼, the N. W. ¼ of Sec. 35. In Sec. 34, the N. E. ¼ and the N. ½ of the S. E. ¼, the S. W. ¼ of Sec. 34, and the S. E. ¼ of the N. W. ¼ of Sec. 34. In Sec. 33, the N. ½ of the S. E. ¼ and

the S. ½ of the N. E. ¼, also in the same section, the N. E. ¼ of the S. W. ¼ and the S. ½ of the S. E. ¼ of the N. W. ¼.

13. Brown drain. The outlet of this drain is into the Cheboyganing river, on the line between sections 22 and 27, Buena Vista township, Saginaw county, T. 13 N., R. 5 E. The drainage area in Merritt township, Bay county, T. 13 N., R. 6 E., is as follows: Sec 30, N. W. ¼, the W. ½ of the N. E. ¼, the N. E. ¼ of the N. E. ¼; Sec. 19, the S. W. ¼, the W. ½ of the S. E. ¼, and the S. E. ¼ of the S. E. ¼.

14. Bublitz drain. The outlet of this drain is into the Quanicassee and Cheboyganing State drain, between sections 13 and 14, Merritt township, T. 13 N., R. 6 E. The drainage area is as follows: In Sec. 13, same township and range, the S. ½ of the N. W. ¼ of the S. W. ¼, the N. ½ of the S. W. ¼, of the S. W. ¼, the S. W. ¼ of the S. W. ¼ of the S. W. ¼; in Sec. 24, the W. ½ of the N. W. ¼ and the E. ½ of the N. E. ¼ in Sec. 23.

15. Budd drain. The outlet of this drain is into Saginaw Bay on the north line of Sec. 6, Pinconning township, T. 17 N., R. 5 E. The drainage areas in the same section are as follows: The north fractional half of the N. fractional half; in Sec. 1, T. 17 N., R. 4 E., the N. fractional half of the N. E. ¼, also the N. ½ of the N. E. ¼ of the N. W. ¼, also in the same section, the N. ½ of the N. W. ¼ of the N. W. ¼; in Sec. 2. the N. fractional half of the N. E. ¼, also the N. fractional ½ of the N. ½ of the N. W. fractional quarter; in Sec. 3, the N. fractional half of the N. ½.

16. Carney Road drain. The outlet of this drain is the end of the Saginaw river in the S. E. ¼ of Sec. 15 T. 14 N., R. 5 E.. The drainage area is as follows: The S. E. fractional ¼ of Sec. 15, the E. ½ of Sec. 22, the E. ½ of Sec. 27, and the S. E. ¼ of the S. W. ¼ of Sec. 27, T. 14 N., R. 5 E.

17. Center Avenue Dredge Cut. The outlet of this drain is into the Saginaw Bay. The drainage area as far as I have been able to obtain the elevations of the same is as follows: In Sec. 27, Hampton township, T. 14 N., R. 6 E., are as follows, the N. W.. ¼; in Sec. 28, same township and range, the N. ½; in Sec. 21, the S. ½; in Sec. 29, the N. ½; in Sec. 20, the S. W. ¼, the W. ½ of the S. E. ¼, and the S. E. ¼ of the S. E. ¼. The location of the outlet is in Tuscola county, T. 14 N., R. 7 E.

18. Chip Road drain. The outlet of this drain is into the north fork of the Kawkawlin river, Sec. 2, T. 14 N., R. 4 E. The drainage area is as follows: In the Bowkowtonden reserve, Sec. 2, the S. ½ of the S. ½, and the N. ½ of the N. ½, in Sec. 3, same township and range, the S. ½ of the S. ½, and the N. ½ of the N. ½,

19. Chute Creek drain. The outlet of this drain is into Saginaw Bay, on the E. and W. ¼ line of Sec. 6, T. 16 N., R. 5 E. The drainage area in the same section is the S. W. fractional quarter of the N. W. fractional ¼; in Sec. 1, T. 16 N., R. 4 E., there is the N. E. ¼ and the N. ½ of the S. E. ¼, the N. W. ¼ and the N. ½ of the S. W. ¼; in Sec. 2, the N. E. ¼, in Sec. 35, Pinconning township, T. 17 N., R. 4 E., there is the S. W. ¼ of the S. E. ¼, also the S. W. ¼. In Sec. 34, same township and range, there is the S. E. ¼; in Sec. 3, T. 16 N., R. 4 E., there is the N. ½ of the N. E. ¼, the N. W. ¼; in Sec. 4, the N. E. ¼, and the S. E. ¼, also the N. ½ of the S. W. ¼ and the S. ½ of the S. ½ of the N. W. ¼; Sec. 5, the S. ½, also the S. ½ of the N. W. ¼; in Sec. 6, the N. ½ of the S. ½, and the S. W. ¼ of the N. W. ¼, T. 16 N., R. 4 E.

20. Coggin's drain. The outlet of this drain is into the Chute Creek drain in the N. E. ¼ of the S. W. ¼ of Sec. 4, Fraser township, T. 16 N., R. 4 E. The drainage area is as follows: The S. E. ¼ and the S. W. ¼ of the S. W. ¼; in Sec. 9, the N. W. ¼ of the N. W. ¼; in Sec. 8, the N. E. ¼, the N. E. ¼ of the N. W. ¼, the S. ½ of the N. W. ¼ and the N. ½ of the S. W. ¼. All in T. 16 N., R. 4 E.

21. Conklin drain. The outlet of this drain is into Saginaw Bay in the N. W. fractional quarter of the S. W. fractional quarter, of Sec. 24, Fraser township, T. 16 N., R. 4 E. Drainage area, the N. W. ¼ of the N. W. fractional quarter of the S. W. fractional quarter of Sec. 24, also the S. W. ¼ of the W. ¼ of the same section. In Sec. 23, the E. ½ of the N. E. ¼, and the N. W. ¼ of the N. E. ¼, the N. W. ¼ of the same section; in Sec. 14, the S. ½.

22. Corbin drain. The outlet of this drain is into the Kawkawlin river on the line between Secs. 32 and 33, Bangor township, T. 15 N., R. 5 E., on the south bank of the river. Drainage area, in Sec. 5, T. 14 N., R. 5 E., is the N. E. fractional ¼ of the N. E. ¼, and the S. E. ¼ of the N. E. ¼, the E. ½ of the S. E. ¼; in Sec. 4, the W. ½ of the N. W. ¼ and the W. ½ of the S. W. ¼; in Sec. 8, the E. ½ of the N. E. ¼, the N. E. ¼ of the S. E. ¼, and the S. E. ¼ of the S. E. ¼; in Sec. 9, the W. ½ of the W. ½.

23. County line drain. The outlet of this drain is into the Quanicassee river in the S. W. ¼ of the S. E. ¼ of Sec. 1, Merritt township, T. 13 N., R. 6 E. The drainage area beginning at the outlet is as follows, in Bay county: The S. E. ¼ of the S. E. ¼, the E. ½ of the E. ½, in Sec. 13; in Sec. 24, the E. ½ of the N. E. ¼, and the N. E. ¼ of the S. E. ¼; and the E. ½ of the S. E. ½ of the S. E. ¼ in Sec. 25, the S. E. ¼ of the N. E. ¼, the E. ½ of the S. E. ¼. This drain is not constructed.

24. Culver Creek drain. The outlet of this drain is into the south fork of the Kawkawlin river in the S. E. ¼ of the N. E. ¼ of Sec. 16, Monitor township, T. 14 N., R. 4 E. Drainage area includes the S. W. ¼ of the S. E. ¼ of the N. E. ¼, the N. W. ¼ of the N. E. ¼ of the S. E. ¼, the N. W. ¼ of the S. E. ¼, the S. W. ¼ of the S. E. ¼, the N. E. ¼ of the S. W. ¼, the S. E. ¼ of the S. W. ¼, in Sec. 16; in Sec. 21, the N. ½ of the N. W. ¼ and the W. ½ of the S. W. ¼ of the N. W. ¼; in Sec. 20, the S. E. ¼ of the N. E. ¼, the S. ½ of the S. W. ¼ of the N. E. ¼, all the S. E. ¼, the S. E. ¼ of the S. W. ¼; in Sec. 29, the N. W. ¼, excepting the N. W. ¼ of the N. W. ¼. In Sec. 30, the N. E. ¼ and the S. E. ¼, also the S. W. ¼; in Sec. 31, the N. ½ of the N. W. ¼.

25. DeCorte drain. The outlet of this drain is into the Young drain at the N. ¼ post of Sec. 32, Portsmouth township, T. 14 N., R. 6 E. Drainage area is as follows: The S. ½ of the N. W. ¼, of the N. E. ¼, the S. W. ¼ of the N. E. ¼, the N. W. ¼ of the N. E. ¼, and the N. ½ of the S. W. ¼ of the S. E. ¼, also in the same section 32, the N. ½ of the S. E. ¼ of the S. W. ¼, the N. E. ¼ of the S. W. ¼, the S. E. ¼ of the N. W. ¼, and the S. ½ of the N. E. ¼ of the N. W. ¼.

26. Dell Creek drain. The outlet of the drain is into the south fork of the Kawkawlin river, on the S. bank where it is intersected by the N. and S. ¼ line of Sec. 12, Williams township, T. 14 N., R. 3 E. The drainage area is as follows: The S. ½ of the S. E. ¼ of the N. W. ¼, Sec. 12, the N. W. ¼ of the S. W. ¼, and the S. W. ¼ of the S. W. ¼ of the same section 12; in Sec. 11, the S. ½ of the S. E. ¼ of the S. E. ¼; in section 14, the N. E. ¼ and the S. E. ¼; in section 13, the W. ½ of the W. ¼; in Sec. 23, the E. ½; in Sec. 24, the W. ½ of the W. ¼; in Sec. 25, the W. ½ of the N. W. ¼, the N. W. ¼ of the S. W. ¼; in Sec. 26, the N. E. ¼ of the S. E. ¼ and the N. E. ¼. This is all in T. 14 N., R. 3 E.

27. Derosia drain. The outlet of this drain is 46 chains north of the S. E. corner of Sec. 18, Monitor township, T. 14 N., R. 4 E., where it empties into a swale, running east northeast, into the south fork of the Kawkawlin river, in Sec. 17, T. 14 N., R. 4 E. Drainage area is the S. E. ¼ of Sec. 18, the N. E. ¼ of Sec. 19, the S. E. ¼ of Sec. 19, the W. ½ of the S. W. ¼, of Sec. 20.

28. Dewey drain. The outlet of this drain is into the north branch of Squaconning creek, between Secs. 33 and 34, Monitor township, T. 14 N., R. 4 E. Drainage area includes the N. E. ¼ of Sec. 33, the W. ½ of the N. W. ¼ of Sec. 34, the E. ½ of the S. E. ¼ of Sec. 28, the W. ½ of the S. W. ¼ of Sec. 27.

29. Dewitt drain. The outlet of this drain is into the Ryon drain on the section line between 22 and 27, Fraser township, T. 16 N., R. 4 E. Drainage area includes the W. ½ of the N. E. ¼ and the E. ½ of the N. W. ¼ of the N. W. ¼ of Sec. 27, the S. ½ of the N. W. ¼, Sec. 27, and the S. W. ¼ of the same section; in section 34, the N. W. ¼ of the N. W. ¼; in Sec. 33, the N. E. ¼ and the N. ½ of the N. W. ¼; in Sec. 28, the S. ½ of the S. E. ¼ and the S. E. ¼ of the S. W. ¼.

30. Dutton drain. This drain empties into the Ryon drain on the line between Secs. 20 and 21, Fraser township, T. 16 N., R. 4 E. Drainage area, in Sec. 20, the E. ½ of the N. E. ¼ and the N. W. ¼ of the N. E. ¼; in Sec. 21, the W. ½ of the N. W. ¼; in Sec. 16, the S. W. ¼ of the S. W. ¼; in Sec. 17, the S. E. ¼ of the S. E. ¼.

31. Eagan drain. The outlet of this drain is into the Monitor drain on the line between Secs. 12 and 13, Monitor township, T. 14 N., R. 4 E. Drainage area, the S. ½ of the S. E. ¼, Sec. 12, and the N. E. ¼ of Sec. 13, T. 14 N., R. 4 E.

32. Edsall drain. The outlet of this drain is into the south fork of the Kawkawlin river, in the N. E. ¼ of the N. W. ¼ of Sec. 10, Monitor township, T. 14 N., R. 4 E. Drainage area, in Sec. 10, is the N. ½ of the N. E. ¼ of the N. W. ¼ and the N. ½ of the N. W. ¼ of the N. W. ¼; in Sec. 3, the S. ½ of the S. W. ¼; in Sec. 4, the S. ½ of the S. ½; in Sec. 9, the N. ½.

33. Ellison drain. The outlet of this drain is into the Munger drain, at the N. W. corner of Sec. 21, Merritt township, T. 13 N., R. 6 E. The drainage area in Sec. 20 is the S. E. ¼ of the N. E. ¼ and the E. ½ of the N. E. ¼ of the N. E. ¼, the N. E. ¼ of the S. E. ¼ and the E. ½ of the S. E. ¼; in Sec. 21, the W. ½ of the N. W. ¼ of the N. W. ¼, the S. W. ¼ of the N. W. ¼, the W. ½ of the S. W. ¼; in Sec. 29, the E. ½ of the N. E. ¼, the N. E. ¼ of the S. E. ¼, the E. ½ of the S. E. ¼ of the S. E. ¼; in Sec. 28, W. ½ of the S. W. ¼, the S. W. ¼ of the N. W. ¼ and the W. ½ of the N. W. ¼, of the N. W. ¼.

34. Flood drain. The outlet of this drain is into the Ryon drain, ⅓ of a mile west of the N. E. corner of Sec. 30, Fraser township, T. 16 N., R. 4 E. Drainage area includes the N. W. ¼ of the N. E. ¼, the N. E. ¼ of the N. W. ¼, the N. W. ¼ of the N. W. ¼, the S. ½ of the N. W. ¼, the N. ½ of the S. W. ¼ and the S. W. ¼ of the S. W. ¼, all in Sec. 30, T. 16 N., R. 4 E. Indirectly this drain receives some water coming from the S. ½ of Sec. 25, Garfield township, T. 16 N., R. 3 E.

36. Forster drain. Outlet into the Culver Creek drain, 993 feet west of the line between Secs. 20 and 21, and 406 feet south of the ¼ section line of Sec. 20, Monitor township, T. 14 N., R. 4 E. Drainage area, in Sec. 20, S. E. ¼ of the S. E. ¼; in Sec. 21,

the S. W. ¼ of the S. W. ¼; in Sec. 28, the W. ½ of the N. W. ¼ and the N. W. ¼ of the S. W. ¼, and the W. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 29, the E. ½ of the N. E. ¼, and the S. E. ¼ of the S. E. ¼.

38. Garfield drain. The outlet of this drain is into Hopler creek, on the line between Secs. 10 and 11, just south of the ¼ post, Williams township, T. 14 N., R. 3 E. Drainage area in Sec. 10, the S. E. ¼ of the S. E. ¼; in Sec. 11, the W. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 14, the W. ½ of the W. ½ of the S. W. ¼; in section 15, the E. ½; in Sec. 22, the E. ½; in Sec. 23, the W. ½ of the W. ½ of the W. ½; in Sec. 27, the N. E. ¼; in Sec. 26, the W. ½ of the W. ½ of the N. W. ¼.

39. Garvie drain. This drain empties into the north fork of the Kawkawlin river in the S. E. ¼ of the S. E. ¼, of Sec. 22, Kawkawlin township, T. 15 N., R. 4 E. Drainage area: In Sec. 22, is the S. W. ¼ of the S. E. ¼; in Sec. 27, the N. ½ of the N. W. ¼; in Sec. 28, is the N. ½ of the N. E. ¼, in Sec. 21, the S. W. ¼ of the S. E. ¼, the S. E. ¼ of the S. W. ¼, and the E. ½ of the S. W. ¼ of the S. W. ¼, all in T. 15 N., R. 4 E.

40. Gates drain. This drain empties into the Tromble drain at the S. ¼ post of Sec. 11, Portsmouth township, T. 13 N., R. 5 E. Drainage area in Sec. 11, the E. ½ of the W. ½, the W. ½ of the N. W. ¼, the N. W. ¼ of the S. E. ¼, and the W. ½ of the S. W. ¼ of the S. E. ¼.

41. Geno drain. This drain has its outlet into Saginaw Bay at the S. ¼ post of Sec. 13, Fraser township, T. 16 N., R. 4 E. Drainage area, the S. ½ of the S. W. ¼ of Sec. 13, the N. ½ of the N. E. ¼ of the N. W. ¼, area 38.6 acres, of Sec. 24, and the N. ½ of the N. W. ¼ of the N. W. ¼, Sec. 24.

42. German Road drain. Outlet into the Quanicassee river on the north side of Sec. 12, Merritt township, T. 13 N., R. 6 E. Drainage area in Sec. 12, the N. ½ of the N. W. ¼ of the N. W. ¼; in Sec. 1, the S. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 2, the S. ½ of the S. E. ¼, the S. E. ¼ of the S. W. ¼, the S. ½ of the S. W. ¼ of the S. W. ¼; in Sec 11, the N. ½ of the N. E. ¼, the N. ½ of the N. W. ¼; in Sec. 10, the N. ½ of the N. E. ¼, and the N. ½ of the N. W. ¼; in Sec. 3, the S. W. ¼ of the S. E. ¼, the S. ½ of the S. E. ¼ of the S. E. ¼, the S. ½ of the S. W. ¼; in Sec. 9, the E. ½ of the N. E. ¼, the N. ½ of the N. W ¼ of the N. E. ¼, the N. ½ of the N. E. ¼ of the N. W. ¼ and the N. ½ of the N. W. ¼ of the N. W. ¼; in Sec. 4, the S. E. ¼ of the S. E. ¼, the S. ½ of the S. W. ¼ of the S. E. ¼, the S. ½ of the S. E. ¼, of the S. W. ¼, the S. W. ¼ of the S. W. ¼; in Sec. 8, the N. ½ of the N. E. ¼, the N. ½ of the N. E. ¼ of the N. W. ¼; in Sec. 5, the S. E. ¼ of the S. E. ¼, the S. ½ of the S. W. ¼ of the S. E. ¼, the S. ½ of the S. E. ¼ of the S. W. ¼, the S. W. ¼ of the S. W. ¼; in Sec. 7, the N. E. ¼ and the N. W. ¼, the N. E. ¼ of the S. W. ¼; in Sec. 6, the S. ½ of the S. ½; in Sec. 1, T. 13 N., R. 5 E., the S. ½ of the S. E. ¼ and the S. E. ¼ of the S. W. ¼; in Sec. 12, the N. E. ¼ of the N. E. ¼, the N. W. ¼ of the N. E. ¼, and the N. E. ¼ of the N. W. ¼.

43. Goetz drain. The outlet of this drain is on the county line between Bay and Saginaw, on the S. line of Sec. 18 into Souwestconing creek, T. 13 N., R. 5 E. The drainage area is as follows: The S. ½ of the S. W. ¼ of the S. E. ¼, the S. ½ of the S. W. ¼ of Sec. 18, T. 13 N., R. 5 E. In Sec. 13, as follows, the S. E. ¼ and the S. W. ¼ and the S. ½ of the N. W. ¼, T. 13 N., R. 4 E. In Sec. 14, the N. ½ of the S. E. ¼ and the S. ½ of the N. E. ¼.

44. Goulette drain. The outlet of this drain is into the N. fork of the Kawkawlin river in the N. E. ¼ of the N. E. ¼ of Sec. 27, T. 15 N., R. 4 E., Kawkawlin township. The drainage area is as follows, in Sec. 27, the S. W. ¼ of the N. E. ¼, the S. ½ of the N. W. ¼; in Sec. 28, the S. E. ¼ of the N. E. ¼ and the S. W. ¼ of the N. E. ¼, the N. E. ¼ of the S. E. ¼, and the N. ½ of the N W. ¼ of the S. E. ¼.

45. Gove drain. The outlet of this drain is into the Railroad drain in the S. E. ¼ of the N. E. ¼ of Sec. 3, Kawkawlin township, T. 15 N., R. 4 E. The drainage area in Sec. 3 is as follows: the W. ½ of the S. E. ¼ of the N. E. ¼, the W. ½ of the N. E. ¼ of the N. E. ¼ and the E. ½ of the N. W. ¼ of the N. E. ¼. In Fraser township, Sec. 34, T. 16 N. R. 4 E., there is drained the E. ½ of the S. W. ¼ and the W. ½ of the S. W. ¼; in Sec. 33, the S. E. ¼ and the S. E. ¼ of the S. W. ¼.

46. Grass Creek drain. The outlet of this drain is into the Quanicassee and Cheboyganing state drain, on the N. line of Sec. 27, Merritt township, T. 13 N., R. 6 E. Drainage area in Bay county is as follows: In Sec. 25, the E. ½ of the N. E. ¼, and the N. ½ of the N. W. ¼ of the N. E. ¼, the N. ½ of the N. ½ of the N. W. ½; in Sec. 24, the S. ½ of the S. E. ¼, the S. E. ¼ of the S. W. ¼ and the S. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 23, the S. ½ of the S. E. ¼, the S. E. ¼ of the S. W. ¼, the S. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 26, the N. ½ of the N. E. ¼ of the N. E. ¼, the W. ½ of the N. E. ¼, the N. W. ¼; in Sec. 27, the N. E. ¼ of the N. E. ¼ of the N. E. ¼.

47. Hampton and Bay Shore drain. Outlet of this drain is into Saginaw bay on the line between Secs. 8 and 9, Hampton township, T. 14 N., R. 6 E. Drainage area is as follows: in Sec. 8, the S. ½ of the N. E. ¼ of the S. E. ¼, the S. ½ of the N. E. ¼; in Sec. 9, the

S. W. ¼ of the S. W. ¼; in Sec. 17, the N. E. ¼ and the S. E. ¼; in Sec. 16, the W. ½; in Sec. 21, the N. W. ¼ of the N. W. ¼; in Sec. 20, the N. ½ of the N. ½; in Sec. 17, the S. W. ¼; in Sec. 18, the S. ½ of the S. E. ¼; in Sec. 19, the N. E. ¼.

48. Hellmuth drain. The outlet of this drain is into the German Road drain at the N. ¼ post of Sec. 8, Merritt township, T. 13 N., R. 6 E., and the S. ¼ post of Sec. 8, where it empties into the Russell drain. Drainage area as follows: The S. ½ of the N. W. ¼ of the N. E. ¼, the S. W. ¼ of the N. E. ¼, the N. W. ¼ of the S. E. ¼, the N. ½ of the S. W. ¼ of the S. E. ¼, in Sec. 8. Also in the same Sec., the N. ½ of the S. ½ of the S. W. ¼, the N. ½ of the S. W. ¼, the S. ½ of the N. W. ¼, the S. ½ of the N. ½ of the N. W. ¼.

49. Histed drain. The principal outlet of this drain is into the German Road drain at the N. E. cor. of Sec. 8, Merritt township, T. 13 N., R. 6 E. This drain is also intersected by the Russell drain at the N. E. corner of Sec. 17, same township and range which would form an outlet E. into the Quanicassee river. The drainage area is as follows: In Sec. 8, the S. ½ of the N. E. ¼ of the N. E. ¼, the S. E. ¼ of the N. E. ¼, the N. E. ¼ of the S. E. ¼, the N. ½ of the S. E. ¼ of the S. E. ¼; in Sec. 9, the S. ½ of the N. W. ¼ of the N. W. ¼, the S. W. ¼ of the N. W. ¼, the N. W. ¼ of the S. W. ¼, the N. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 16, the S. ½ of the N. W. ¼ of the N. W. ¼, the S. W. ¼ of the N. W. ¼, the N. W. ¼ of the S. W. ¼, the N. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 17, the S. ½ of the N. E. ¼ of the N. E. ¼, the S. ½ of the N. E. ¼, the N. ½ of the S. E. ¼, the N. ½ of the S. E. ¼ of the S. E. ¼.

50. Hopler Creek drain. The outlet of this drain is into the south fork of the Kawkawlin river in the S. E. ¼ of the N. W. ¼ of Sec. 12, Williams township, T. 14 N., R. 3 E. The drainage area includes the following land subdivisions: The S. W. ¼ of the N. W. ¼ of Sec. 12; in Sec. 11, the S. E. ¼ of the N. E. ¼, the S. W. ¼ of the N. E. ¼, the N. W. ¼ of the S. E. ¼, the S. E. ¼ of the N. W. ¼, the N. E. ¼ of the S. W. ¼, the N. W. ¼ of the S. W. ¼, the S. W. ¼ of the N. W. ¼; in Sec. 10, the S. E. ¼, the S. E. ¼ of the N. E. ¼, the S. ½ of the S. W. ¼ of the N. E. ¼, the S. W. ¼ of Sec. 10; in Sec. 9, the S. E. ¼ and the S. ½ of the S. W. ¼; in Sec. 16, the N. E. ¼, the W. ½ of the S. E. ¼, the N. W. ¼ and the S. W. ¼; in Sec. 17, the N. ½ of the S. E. ¼, the S. ½ of the N. E. ¼; in Sec. 20, the W. ½ of the N. E. ¼, the W. ½ of the S. E. ¼, the S. W. ¼; in Sec. 29, the W. ½ and the W. ½ of the E. ½; in Sec. 30, the E. ½; in Sec. 31, the N. E. ¼ of the N. E. ¼; in Sec. 32 the N. ½. This drain has not been dug. The lower reaches of the drainage area given is occupied by swamp land situated E. of the Tittabawassee moraine.

51. Hopp drain. The outlet of this drain is into the Russell drain at the N. ¼ post of Sec. 15, Merritt township, T. 13 N., R. 6 E. The drainage area is as follows: The S. ½ of the N. W. ¼ of the N. E. ¼, the S. W. ¼ of the N. E. ¼, the N. W. ¼ of the S. E. ¼, the N. ½ of the S. W. ¼ of the S. E. ¼, all in Sec. 15. Also in the same section the S. ½ of the N. E. ¼ of the N. W. ¼, the S. E. ¼ of the N. W. ¼, the N. E. ¼ of the S. W. ¼ the N. ½ of the S. E. ¼ of the S. W. ¼.

52. Indian Town drain. The outlet of this drain commences at a point on the N. bank of the Kawkawlin river where the E. line of Lot 3, Sec. 5, T. 14 N., R. 5 E., intersects same. This is in the S. W. ¼ of the N. W. ¼ of said Sec. 5. The drainage area embraces the following lands: The N. W. ¼ of the N. W. ¼ of Sec. 5; in Sec. 6, the N. E. ¼ of the N. E. ¼, the N. ½ of the N. W. ¼ of the N. E. ¼. Secs. 5 and 6 are in T. 14 N., R. 5 E. In Sec. 31, T. 15 N., R. 5 E, there is drained the S. W. ¼ of the S. E. ¼, the W. ½ of the S. E. ¼ of the S. E. ¼, the S. W. ¼; in Sec. 36, Kawkawlin township, T. 15 N., R. 4 E., there is the N. E. ¼ and the N. W. ¼ of the S. E. ¼, also the N. E. ¼ of said section.

53. Jonas drain. The outlet of this drain is into the Town Line drain at the N. ¼ post of Sec. 4, Portsmouth township, T. 13 N., R. 6 E. The drainage area is as follows: In Sec. 4, the S. ½ of the N. W. ¼ of the N. E. ¼, the S. W. ¼ of the N. E. ¼, the N. W. ¼ of the S. E. ¼, the N. ½ of the S. W. ¼ of the S. E. ¼. On the W. side of the drain the N. ½ of the S. E. ¼ of the S. W. ¼, the N. E. ¼ of the S. W. ¼, the S. E. ¼ of the N. W. ¼ and the S. ½ of the N. E. fractional ¼ of the N. W. fractional ¼. This fractional ¼ has an area of 38.34 acres.

54. Jones drain. The outlet of this drain is into the Railroad drain on the line between Secs. 8 and 9, just N. of the N. 80-rod corner, Kawkawlin township, T. 15 N., R. 4 E. The drainage area in Sec. 8 includes the S. ½ of the N. E. ¼ of the N. E. ¼, the S. E. ¼ of the N. E. ¼, the S. W. ¼ of the N. E. ¼, and the S. ½ of the N. W. ¼ of the N. E. ¼, the N. ½ of the S. W. ¼, the S. ½ of the N. W. ¼; in Sec. 7, the S. E. ¼ of the N. E. ¼, the N. E. ¼ of the S. E. ¼.

55. Keister drain. The outlet of this drain is into the Young drain in the N. E. ¼ of Sec. 31, Portsmouth township, T. 14 N., R. 6 E. The drainage area is the S. ½ of the N. E. ¼ of the N. E. ¼; the N. ½ of the S. E. ¼ of the N. E. ¼ in Sec. 31; in Sec. 32, the S. ½ of the N. W. ¼ of the N. W. ¼, the S. W. ¼ of the N. W. ¼.

56. Kenney drain. This ditch has its outlet into the Quanicassee and Cheboyganing

State drain on the N. line of Sec. 34, Merritt township, T. 13 N., R. 6 E. Lands which are tributary to this drain are as follows: In Sec. 34, the N. W. ¼ of the N. W. ¼; in Sec. 27, the S. W. ¼ of the S. W. ¼; in Sec. 28, the S. ½ of the S. E. ¼, the S. E. ¼ of the S. W. ¼, the E. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 33, the N. ½ of the N. E. ¼, the N. ½ of the N. W. ¼; in Sec. 32, the N. ½ of the N. ½; in Sec. 29, the S. ½ of the S. ¼, the S. W. ¼ of the S. E. ¼, the S. E. ¼ of the S. W. ¼, and the S. ½ of the S. W. ¼ of the S. W. ¼. Where this drain is crossed by the Tuscola Stone road on the N. line of Sec. 32, T. 13 N., R. 6 E., there is a divide, the waters flowing E. and W. The western outlet of the drain is into the Treiber ditch at the N. W. corner of Sec. 32, T. 13 N., R. 6 E.

57. Kerr drain and extension. The outlet of this drain is into the north fork of the Kawkawlin river in the N. E. ¼ of the S. E. ¼ of Sec. 22, Kawkawlin township, T. 15 N., R. 4 E. The elevation here is 591.75 A. T. The drainage area in Sec. 22 includes the S. E. ¼ of the N. E. ¼, the N. E. ¼ of the N. E. ¼; in Sec. 23 the N. W. ¼ of the N. W. ¼, the S. W. ¼ of the N. W. ¼; in Sec. 14, that part of the W. ½ of the W. ½ lying W. of the East Saginaw and Ausable Stone road; in Sec. 15, the S. E. ¼, the S. ½ of the N. E. ¼, the N. E. ¼ of the N. E. ¼, the S. ½ of the N. W. ¼ of the N. E. ¼; in Sec. 10, the S. E. ¼ of the S. E. ¼.

58. Kleinart drain. This drain has its outlet into the Quanicassee and the Cheboyganing State drain on the N. and S. ¼ line of Sec. 27, Merritt township, T. 13 N., R. 6 E. The drainage area in Sec. 27 includes the S. ½ of the S. E. ¼; in Sec. 34, the N. E. ¼, the W. ½ of the S. E. ¼, the E. ½ of the S. W. ¼.

59. Knodle drain. This drain has its outlet into the Ryon drain in the N. E. ¼ of the N. E. ¼ of Sec. 28, Frazer township, T. 16 N., R. 4 E. The drainage area in Sec. 28 includes the N. ½; in Sec. 21, the S. ½ of the S. W. ¼; in Sec. 20, the S. ½ of the S. E. ¼, the S. E. ¼ of the S. W. ¼, the S. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 29, the N. ½ in Sec. 30, the N. E. ¼ of the N. E. ¼; in Sec. 19, the S. E. ¼ of the S. E. ¼ of the S. E. ¼.

60. Kosciuszko drain. This drain has its outlet into Hopler creek, just N. of the W. ¼ post of Sec. 16, Williams township, T. 14 N., R. 3 E. The drainage area in Sec. 16 includes the N. W. ¼ of the S. W. ¼, the S. W. ¼ of the S. W. ¼; in Sec. 21, the E. ½ of the N. W. ¼ of the N. W. ¼, the E. ½ of the N. W. ¼, the E. ½ of the S. W. ¼ of the N. W. ¼. South of the Midland Stone road in the same Sec. 21 there is the E. ½ of the S. W. ¼, the E. ½ of the E. ½ of the S. W. ¼, the W. ½ of the S. E. ¼; in Sec. 28, the W. ½ and the W. ½ of the E. ½; in Sec. 33, the N. E. ¼ of the N. W. ¼, the N. W. ¼ of the N. E. ¼.

61. Kraner drain. This drain empties into the Monitor drain on the N. 80 rod line of Sec. 23 in the N. E. ¼ of Monitor township, T. 14 N., R. 4 E. The drainage area includes the E. ½ of the S. E. ¼ of the N. E. ¼ of Sec. 23; in Sec. 24, the S. W. ¼ of the N. W. ¼, the S. E. ¼ of the N. W. ¼, the N. E. ¼ of the S. W. ¼, and the N. W. ¼ of the S. W. ¼.

62. Lapan drain. This drain has its outlet into the Bedell drain on the line between Secs. 20 and 21, Kawkawlin township, T. 15 N., R. 4 E. The drainage area in Sec. 20 includes the following subdivisions: The S. ½ of the S. E. ¼ of the N. E. ¼, the E. ½ of the S. E. ¼, the S. W. ¼ of the S. E. ¼, the S. E. ¼ of the S. W. ¼, the S. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 30, the N. E. ¼ of the N. E. ¼; in Sec. 29, the N. ½ of the N. ½, in Sec. 28, the N. W. ¼ of the N. W. ¼; in Sec. 21, the N. W. ¼ of the S. W. ¼, the W. ½ of the S. W. ¼ of the N. W. ¼.

63. LaPaussee drain. This drain has its outlet into Saginaw Bay on the line between Secs. 6 and 7, Frazer township, T. 16 N., R. 5 E. The drainage area in Sec. 1, T. 16 N., R. 4 E., is as follows: The S. ½ of the S. ½; in Sec. 12, the N. ½ of the N. ½ of the N. ½; in Sec. 11, the N. ½ of the N. ½ of the N. E. ¼, the N. ½ of the N. W. ¼; in Sec. 2, the S. W. ¼, the S. ½ of the S. E. ¼.

64. Lehman drain. This drain has two outlets. The northerly one into the Town Line drain at the N. E. corner of Sec. 3, Merritt township, T. 13 N., R. 6 E.; the southerly one into the German Road drain at the S. E. corner of Sec. 3. This drain is also bisected by the Schoof drain emptying into the Quanicassee river. The drainage area in Sec. 3 includes the S. ½ of the N. E. fractional 40, area 39.65 acres, of the N. E. ¼, the S. E. ¼ of the N. E. ¼ excepting the lower half. The S. ½ of the N. E. ¼ of the S. E. ¼, the N. ½ of the S. E. ¼ of the S. E. ¼; in Sec. 2, the N. W. ¼ of the S. W. ¼ of the S. W. ¼, the S. W. ¼ of the N. W. ¼ of the S. W. ¼, the N. W. ¼ of the S. W. ¼ of the N. W. ¼, the S. W. ¼ of the N. W. ¼ of the N. W. ¼.

65. Lesperance drain. This drain was dug during the high water of May, 1884, when the shore of the bay extended W. to the N. and S. ¼ line of Sec. 24, T. 15 N., R. 4 E. At the present time the area between the former and present shore line is occupied by swamp land. The outlet, in May, 1884, was on the N. and S. ¼ line of Sec. 24 and 27 rods N. of the center of the section. The drainage area in Sec. 24 includes the S. ½ of the N. W. ¼, the N. ½ of the S. W. ¼; in Sec. 23, the S. ½ of the N. E. ¼, the N. ½ of the S. E. ¼, the S. E. ¼ of the N. W. ¼, that part lying E. of the East Saginaw and Ausable Stone road. In the N. E. ¼ of the S. W. ¼ the area E. of the same stone road.

66. Linwood drain. This drain empties into Saginaw Bay on the town line between Secs. 36 and 1, T. 15 N., R. 4 E. and T. 16 N., R. 4 E. This drain has not been dug. In Sec. 2, T. 15 N., R. 4 E., the drainage area includes the N. ½ of the N. ½; in Sec. 3, the N. ½ of the N. ½; in Sec. 4, the N. ½, and the N. W. ¼ of the S. W. ¼; in Sec. 5, the N. ½, the N. ½ of the S. E. ¼, also the N. ½ of the S. W. ¼; in Sec. 6, the N. E. ¼ of the N. E. ¼, the N. ½ of the N. W. ¼ of the N. E. ¼, the N. ½ of the N. W. ¼; in Sec. 1, Beaver township, T. 15 N., R. 3 E., the N. E. ¼ of the N. E. ¼; in Sec. 35, T. 16 N., R. 4 E., the S. ½ of the S. ½ of the S. E. ¼, also the S. ½ of the S. ½ of the S. W. ¼; in Sec. 34, the S. ½ of the S. E. ¼ of the S. E. ¼, the S. ½ of the S. W. ¼ of the S. E. ¼; in Sec. 31, the S. ½ of the S. E. ¼, and the S. ½ of the S. W. ¼. In Garfield township, T. 16 N., R. 3 E., there is the S. E. ¼ of the S. E. ¼.

67. Livingston drain. This drain empties into Willard creek at a point 11.50 chains south and 21.80 chains east of the corner of Secs. 28, 29, 32, 33, Beaver township, T. 15 N., R. 3 E. The drainage area embraces, in Sec. 33, the S. ½ of the N. W. ¼ of the N. W. ¼; in Sec. 32, the S. ½ of the N. E. ¼, the N. ½ of the S. E. ¼, the S. E. ¼ of the N. W. ¼, the S. W. ¼; in Sec. 31, the S. E. ¼ of the S. E. ¼.

68. McNelly drain. This drain has its outlet into the No. 1 drain in the S. W. ¼ of the S. E. ¼ of Sec. 28, T. 15 N., R. 4 E. The grade line of the drain is rather high and was apparently run for the purpose of draining a swamp situated in the center of Sec. 29. The drainage area is as follows in Sec. 28: The N. W. ¼ of the S. E. ¼, the N. ½ of the S. W. ¼, the N. ½ of the S. ½ of the S. W. ¼; in Sec. 29, the N. ½ of the S. E. ¼, the S. ½ of the N. E. ¼, the S. E. ¼ of the N. W. ¼, the N. E. ¼ of the S. W. ¼.

69. Meed drain. This drain has its outlet into the Baxman drain at the W. ¼ post of Sec. 30, T. 14 N., R. 5 E. The drainage area is as follows: The W. ½ of the N. W. ¼ of Sec. 30, the S. ½ of the S. W. ¼ of Sec. 19.

70. Meger drain. The outlet of this drain is into the Russell drain at the N. ¼ post. of Sec. 16, Merritt township, T. 13 N., R. 6 E. The drainage area in Sec. 16 includes the N. E. ¼ of the S. W. ¼, the W. ½ of the N. W. ¼ of the S. E. ¼, the S. E. ¼ of the N. W. ¼, the W. ½ of the S. W. ¼ of the N. E. ¼, the E. ½ of the N. E. ¼ of the N.W. ¼, the W. ½ of the N. W. ¼ of the N. E. ¼.

71. Meiers drain. This drain empties into the Keister ditch at the E. ¼ post of Sec. 31, T. 14 N., R. 6 E. Drainage area in said Sec. 31 includes the S. ½ of the N. E. ¼, the S. E. ¼ of the N. W. ¼, the S. ½ of the S. W. ¼ of the N. W. ¼, the N. ½ of the S. E. ¼, the N. E. ¼ of the S. W. ¼, the E. ½ of the N. W. ¼ of the S. W. ¼, and the N. W. ¼ of the N. W. ¼ of the S. W. ¼.

72. Merrill drain. This drain empties into the Saginaw Bay on the line between Secs. 8 and 9, Hampton township, T. 14 N., R. 6 E Along the E. line of Secs. 8 and 17 this drain has the same course as the Hampton and Bay Shore drain, which drain see for drainage areas. Between Secs. 20 and 21 this drain was continued in another direction and has the following drainage area: In Sec. 20, the E. ½ of the N. E. ¼ of the N. E. ¼, the S. ½ of the N. E. ¼, the S. E. ¼; in Sec. 29, the N. E. ¼; in Sec. 21, the W. ½ of the W. ½.

73. Mills drain. This drain empties into the Bangor and Monitor State drain in the center of Sec. 7, Bangor township, T. 14 N., R. 5 E. The drainage area in said Sec. 7 includes the N. E. ¼, the N. ½ of the N. W. ¼ of the S. E. ¼, the N. E. ¼ of the S. E. ¼.

74. Michie Creek drain. This drain has its outlet into Saginaw Bay on the E. and W. ¼ line of Sec. 7, Frazer township, T. 16 N., R. 5 E. This drain follows a natural water course which has only been straightened out as far as the East Saginaw and AuSable State road. On the W. 80-rod line of Sec. 11, T. 16 N., R. 4 E. The drainage area in Sec. 12 includes the S. ½ of the N. E. ¼, the N. ½ of the S. E ¼, the S. ½ of the N. W. ¼, the N. ½ of the S. W. ¼; in Sec. 11, the S. ½ of the N. ½, the N. ½ of the S. ½; in Sec. 10, the S. ½; in Sec. 9, the S. ½; in Sec. 16, the N. ½; in Sec. 17, the N. ½; in Sec. 8, the S. ½ of the S. ½; in Sec. 7, the S. ½ of the S. ½; in Sec. 18, the N. ½; in Garfield township, T. 16 N., R. 3 E., the S. ½ of Sec. 12; in Sec. 13, the N. ½; in Sec. 14, the N. ½; in Sec. 11, the S. ½, and the S. ½ of the N. ½; in Sec. 10, the S. ½, and the S. ½ of the N. ½; in Sec. 15, the N. ½; in Sec. 9, the S. E. ¼; in Sec. 16, by way of a tributary, the N. E. ¼. On the E. line of Sec. 11 this drain has an elevation of 48 feet above the bay at its present elevation.

75. Monitor drain. In Sec. 1 of Monitor township, T. 14 N., R. 4 E., this drain has the same course as the Bangor and Monitor State drain into which it empties on the N. and S. ¼ line of Sec. 12, 40 rods N. of the center, T. 14 N., R. 4 E. The drainage area beyond this point is as follows: In Sec. 12, the E. ½ of the S. W. ¼ and the W. ½ of the S. W. ¼, the N. W. ¼ of the S. E. ¼, the N. ½ of the S. W. ¼ of the S. E. ¼; in Sec. 13, the W. ½, the S. ½ of the N. W. ¼ of the N. E. ¼, the S. W. ¼ of the N. E. ¼, the W. ½ of the S. E. ¼; in Sec. 14, the E. ½; in Sec. 23, the N. ½ of the N. E. ¼, the S. W. ¼ of the N E. ¼, the E. ½ of the N. W. ¼, the W. ½ of the S. E. ¼, and the E. ½ of the S. W. ¼.

76. Nickel drain has its outlet into the Garvie drain in the S. E. ¼ of the S. W. ¼ of Sec. 22, Kawkawlin township, T. 15 N., R. 4 E. The drainage area in said Sec. 22 includes the S. E. ¼ of the S. W. ¼, the W. ½ of the S. W. ¼; in Sec. 21, the S. ½ of the N. E. ¼ of the S. E. ¼, the N. ½ of the S. E. ¼ of the S. E. ¼.

77. No. 1 drain. This ditch empties into the north fork of the Kawkawlin river in the S. E. ¼ of the S. E. ¼ of Sec. 27, Kawkawlin township, T. 15 N., R. 4 E. The drainage area in said Sec. 27, includes the S. E. ¼ of the S. W. ¼, the S. W. ¼ of the S. E. ¼, the S. W. ¼ of the S. W. ¼; in Sec. 34, the N. ½ of the N. W. ¼; in Sec. 28, the S. E. ¼ of the S. E. ¼; in Sec. 33, the N. ½, and the N. ½ of the S. W. ¼; in Sec. 32, the N. ½ of the S. ½, the S. ½ of the N. ½, and the N. ½ of the N. ½; in Sec. 29, the S. W. ¼ of the S. W. ¼; in Sec. 31, the N. E. ¼; in Sec. 30, the S. E. ¼, the E. ½ of the S. W. ¼, the E. ½ of the N. W. ¼.

78. Phillips drain. This drain empties into the south fork of the Kawkawlin river on the line between Secs. 7 and 12, T. 14 N., R. 4 E. and T. 14 N., R. 3 E. This drain is ill adapted for its purpose. The drainage area includes, in said Sec. 12, the S. E. ¼ of the S. E. ¼; in Sec. 13, the E. ½; in Sec. 24, the E. ½. Secs. 12, 13 and 24 are in T. 14. N., R. 3 E. In T. 14 N., R. 4 E., Sec. 18, the W. ½ of the W. ½; in Sec. 19, the W. ½ of the W. ½.

79. Pinconning drain. This drain empties into the Saginaw Bay on the line between Secs. 7 and 18, T. 17 N., R. 5 E. This ditch has the following drainage areas: In Sec. 7, the S. W. ¼ of the S. W. ¼; in Sec. 18, the N. W. ¼ of the N. W. ¼. In T. 17 N., R. 4 E., the S. ½ of Secs. 12, 11, 10, 9; in Sec. 8, the E. ½ of the N. E. ¼ of the S. E. ¼, the S. ½ of the S. E. ¼, the S. ½ of the S. ½ of the S. W. ¼, the N. ½ of the N. ½ of Sec. 17; of Sec. 16, the N. ½ of the N. ½; the N. ½ of Sec. 15; the N. ½ of Sec. 14; in Sec. 13, that part of the N. W. ¼ lying W. of the E. Saginaw and Ausable State road; in Sec. 13, the N. ½ of the N. E. ¼.

80. Pommerville drain and Extension. This drain has its outlet into the Grass Creek drain at the N. ¼ post of Sec. 25, T. 13 N., R. 6 E. The drainage area in Sec. 25 has the N. W. ¼ of the N. W. ¼ of the N. E. ¼, the S. ½ of the N. W. ¼ of the N. E. ¼, the S. W. ¼ and the S. E. ¼ of the N. E. ¼, the S. E. ¼, the E. ½ of the W. ½; in Sec. 36, the E. ½ and the E. ½ of the W. ½.

82. Quanicassee and Cheboyganing State drain. In its course in Bay county this drain has its outlet into the Quanicassee river or estuary in the N. W. ¼ of the S. W. ¼ of Sec. 12, T. 13 N., R. 6 E. The drainage area directly tributary to this in Sec. 13 is as follows: The N. W. ¼, the N. ½ of the N. W. ¼ of the S. W. ¼, the N. E. ¼ of the S. W. ¼; in Sec. 14, the S. ½ of the S. E. ¼, the N. E. ¼ of the S. E. ¼; in Sec. 23, the W. ½ of the N. E. ¼, the S. E. ¼ of the N. W. ¼, the N. E. ¼ of the S. W. ¼, the N. W. ¼ of the S. E. ¼; in Sec. 22, the S. E. ¼ of the S. E. ¼; in Sec. 27, the S. ½ of the N. E. ¼ and the S. ½ of the N. W. ¼, the N. ½ of the S. W. ¼, the N. ½ of the S. E. ¼; in Sec. 34, the S. ½ of the N. W. ¼, the N. W. ¼ of the S. W. ¼, the S. W. ¼ of the S. W. ¼; in Sec. 33, the S. E. ¼.

83. Quarter Line drain. Empties into the Young drain at the N. ¼ post of Sec. 33, Portsmouth township, T. 14 N., R. 6 E. The drainage area in said Sec. 33 includes the W. ½ of the N. W. ¼ of the N. E. ¼, the E. ½ of the N. E. ¼ of the N. W. ¼, the S. W. ¼ of the N. E. ¼, the N. W. ¼ of the S. E. ¼, the W. ½ of the S. W. ¼ of the S. E. ¼, the S. E. ¼ of the S. W. ¼, the E. and N. ½ of the S. E. ¼ of the S. W. ¼, the N. E. ¼ of the S. W. ¼, the S. E. ¼ of the N. W. ¼.

84. Railroad drain. This drain has its outlet into Saginaw Bay on the ¼ line of Sec. 1, Kawkawlin township, T. 15 N., R. 4 E. The drainage area in Sec. 2 is the N. ½ of the S. E. ¼ and the S. ½ of the N. E. ¼, the N. ½ of the S. W. ¼, and the S. ½ of the N. W. ¼; in Sec. 3 the E. ½ of the S. E. ¼ of the N. E. ¼, the N. E. ¼ of the S. E. ¼, the S. E. ¼ of the N. W. ¼, the N. ½ of the N. E. ¼ of the S. W. ¼, the N. W. ¼ of the S. W. ¼; in Sec. 4, the S. E. ¼, and the S. ½ of the S. E. ¼; in Sec. 9, the N. ½ of the N. E. ¼, the N. W. ¼; in Sec. 8, the N. ½ of the N. E. ¼ of the N. E. ¼, the N. ½ of the N. W. ¼ of the N. E. ¼, the N. ½ of the N. W. ¼; in Sec. 5, the S. ½ of the S. ½; in Sec. 7, the N. E. ¼ and the N. W. ¼ of the N. E. ¼, the N. E. ¼ of the N. W. ¼; in Sec. 6, the S. E. ¼. Since that time the drain has been extended into Garfield township.

85. Ratell drain. This drain empties into the Bennett drain and the Grass Creek drain at the N. W. corner of Sec. 25, Merritt township, T. 13 N., R. 6 E. The drainage area in said Sec. 25 includes the W. ½ of the N. W. ¼ of the N. W. ¼, the S. W. ¼ of the N. W. ¼, the W. ½ of the S. W. ¼; in Sec. 36, the N. W. ¼ of the N. W. ¼; in Sec. 35, the N. E. ¼ of the N. E. ¼; in Sec. 26, the S. E. ¼, the S. E. ¼ of the N. E. ¼, the E. ½ of the N. E. ¼ of the N. E. ¼.

86. Robbins drain. This drain has its outlet into the Cheboyganing creek on the E. and W. ¼ line of Sec. 35, Zilwaukie township, Saginaw county, T. 13 N., R. 5 E. The drainage area in Sec. 31, Merritt township, T. 13 N., R. 6 E., includes the S. ½ of the N.

½, and the N. ½ of the S. ½, taking into account the Vigor drain on the S. line of 31, which was never dug.

87. Rosebush drain. Empties into Saginaw Bay in the S. W. fractional ¼ of the S. W. fractional ¼ of Sec. 36, Frazer township, T. 16 N., R. 4 E. The drainage area in Sec. 35 includes the N. ½ of the S. ½, and the S. ½ of the N. ½ of said Sec. 35; in Sec. 34, the N. E. ¼ of the S. E. ¼, and the N. ½ of the S. E. ¼ of the S. E. ¼.

88. Russell drain. Has its outlet into the Quanicassee river on the N. line of Sec. 14, Merritt township, T. 13 N., R. 6 E. The drainage area in said Sec. 14 includes the N. ½ of the N. W. ¼ of the N. E. ¼, the N. E. ¼ of the N. W. ¼, the E. ½ and the N. ½ of the N. W. ¼ of the N. W. ¼; in Sec. 11, the S. W. ¼ of the S. E. ¼, the S. W. ¼; in Sec. 10, the S. ½; in Sec. 15, the N. ½ of the N. E. ¼ of the N. E. ¼, the N. ½ of the N. W. ¼ of the N. E. ¼, the N. ½ of the N. ½ of the N. W. ¼, and the S. ½ of the N. W. ¼ of the N. W. ¼, the S. W. ¼ of the N. W. ¼; in Sec. 16, the E. ½ of the N. E. ¼ and the E. ½ of the W. ½ of the N. E. ¼, the N. ½ of the N. W. ¼ of the N. E. ¼, the W. ½ of the N. E. ¼ of the N. W. ¼, the E. ½ of the W. ½ of the N. W. ¼, the N. ½ of the N. W. ¼ of the N. W. ¼; in Sec. 9, the S. ½ of the S. E. ¼, the N. E. ¼ of the S. E. ¼, the E. ½ of the N. W. ¼ of the S. E. ¼, the S. ½ of the S. ½ of the S. W. ¼; in Sec. 8, the S. ½ of the S. ½ of the S. E. ¼, the N. ½ of the S. W. ¼ of the S. E. ¼, the S. ½ of the S. ½ of the S. W. ¼, the N. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 17, the W. ½ of the N. E. ¼ of the N. E. ¼; in Sec. 18, the N. ½, the W. ½ of the N. E. ¼, the N. ½ of the N. W. ¼; in Sec. 7, the S. ½ of the S. ½; in T. 13 N., R. 5 E., Sec. 12, the E. ½ of the S. ½ of the S. E. ¼; in Sec. 13, the N. E. ¼ of the N. E. ¼.

89. Ryon drain. This drain follows a natural water course emptying into Saginaw Bay on the N. 80-rod line of Sec. 26, Frazer township, T. 16 N., R. 4 E. The drainage area includes the S. fractional ½ of the N. fractional ½ of said Sec. 26, the S. ½ of the N. ½ of Sec. 26; in Sec. 27 the S. ½ of the N. E. ¼ of the N. E. ¼, the S. E. ¼ of the N. E. ¼, the N. E. ¼ of the S. E. ¼, the N. W. ¼ of the S. E. ¼, the S. W. ¼ of the N. E. ¼, and the N. W. ¼ of the N. E. ¼, the N. E. ¼ of the N. E. ¼ of the N. W. ¼; in Sec. 22, the S. ½ of the S. W. ¼ of the S. E. ¼, the S. ½ of the S. W. ¼; in Sec. 28, the N. E. ¼ of the N. E. ¼ of the N. E. ¼; in Sec. 21, the E. ½ of the S. E. ¼, the N. W. ¼ of the S. E. ¼, the N. ½ of the S. W. ¼ of the S. E. ¼, the N. ½ of the S. W. ¼, the N. ½ of the S. ½ of the S. W. ¼, the S. ½ of the N. W. ¼; in Sec. 20, the W. ½ of the S. E. ¼ of the N. E. ¼, the S. W. ¼ of the N. E. ¼, the N. W. ¼, the N. ½ of the S. E. ¼, and the N. ½ of the S. W. ¼; in Sec. 19, the S. ½, and the S. ½ of the N. ½.

90. Schimbine drain. This drain has its outlet into Davis creek in the N. W. ¼ of the N. E. ¼ of Sec. 28, Beaver township, T. 15 N., R. 3 E. The elevation here is 36 feet above the Bay. The drainage area includes the S. ½ of the N. W. ¼ of the N. E. ¼, the S. W. ¼ of the N. E. ¼, the S. ½ of the N. E. ¼ of the N. W. ¼, the S. ½ of the N. W. ¼ and the N. ½ of the S. W. ¼; in Sec. 29, the N. E. ¼ of the S. E. ¼, the S. E. ¼ of the N. E. ¼.

91. Schoeneck drain. Empties into the Russell drain at the S. ¼ post of Sec. 9, Merritt township, T. 13 N., R. 6 E. The drainage area includes the E. ½ and the N. ½ of the S. E. ¼ of the S. W. ¼, the N. E. ¼ of the S. W. ¼, the S. E. ¼ of the N. W. ¼, the E. ½ of the N. E. ¼ of the N. W. ¼, the W. ½ of the N. W. ¼ of the N. E. ¼, the S. W. ¼ of the N. E. ¼, the N. W. ¼ of the S. E. ¼, the W. ½ of the S. W. ¼ of the S. E. ¼. This is all in Sec. 9.

92. Schoof drain. This drain has its outlet into the Quanicassee river on the E. and W. ¼ line of Sec. 1, Merritt township, T. 13 N., R. 6 E. The drainage area embraces the S. W. ¼ of the N. W. ¼ of said Sec. 1, and the N. W. ¼ of the S. E. ¼; in Sec. 2, the N. ½ of the S. E. ¼, the S. ½ of the N. E. ¼, the S. E. ¼ of the N. W. ¼, the N. E. ¼ of the S. W. ¼, the E. ½ and the N. ½ of the N. W. ¼ of the S. W. ¼, the E. ½ and the S. ½ of the S. W. ¼ of the N. W. ¼; in Sec. 3, the W. ½ of the N. E. ¼ of the S. E. ¼, the N. W. ¼ of the S. E. ¼, the N. ½ of the S. W. ¼, the S. ½ of the N. W. ¼, the S. W. ¼ of the N. E. ¼, the W. ½ and the S. ½ of the S. E. ¼ of the N. E. ¼.

93. Schumacker drain. Empties into the Quanicassee and Cheboyganing State drain on the N. line of Sec. 27, Merritt township, T. 13 N., R. 6 E. The drainage area is as follows: The N. ½ of the N. W. ¼ of the N. E. ¼ in Sec. 27, also in the same Sec. the N. ½ of the N. W. ¼, the S. W. ¼ of the N. W. ¼, the W. ½ of the S. E. ¼ of the N. W. ¼; in Sec. 28, the N. E. ¼, the E. ½ of the N. W. ¼, the E. ½ and the N. ½ of the N. W. ¼ of the N. W. ¼; in Sec. 21, the S. ½ and the E. ½ of the S. W. ¼ of the S. W. ¼, the S. E. ¼ of the S. W. ¼, the S. ½ of the S. E. ¼; in Sec. 22, the S. ½ of the S. W. ¼, the S. W. ¼ of the S. E. ¼.

94. Schwab drain. This drain has its outlet into the Edsall drain at the N. E. corner of Sec. 8, Monitor township, T. 14 N., R. 4 E. The drainage area includes the S. E. ¼ of Sec. 5, the S. W. ¼ of Sec. 5, the S. ½ of the N. ½ of the same section, the S. ½ of Sec. 6, the S. ½ of the N. ½ of the same section.

95. Secord drain. This drain empties into Saginaw Bay on the N. line of Sec. 26,

Frazer township, T. 16 N., R. 4 E. The drainage area includes the N. ½ of the N. ½ of the N. ½ of Sec. 26, the S. ½ of the S. W. ¼ of Sec. 23; in Sec. 22, the S. E. ¼.

96. Senay drain. Emptying into the Railroad drain on the N. and S. ¼ line of Sec. 3, Kawkawlin township, T. 15 N., R. 4 E. The drainage area in said Sec. 3 includes the S. E. ¼ of the S. W. ¼, the S. W. ¼ of the S. E. ¼, the S. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 10, the N. W. ¼.

98. Schindahatte drain. This drain empties into the Young drain at the N. E. corner of Sec. 35, Portsmouth township, T. 14 N., R. 5 E. The drainage area in said Sec. 35 includes the E. ½ and the S. ½ of the N. E. ¼ of the N. E. ¼, the S. E. ¼ of the N. E. ¼, the N. E. ¼ of the S. E. ¼, the E. ½ and the N. ½ of the S. E. ¼ of the S. E. ¼; in Sec. 36, the W. ½ and the S. ½ of the N. W. ¼ of the N. W. ¼, the S. W. ¼ of the N. W. ¼, the N. W. ¼ of the S. W. ¼, the W. ½ of the S. W. ¼ of the S. W. ¼.

99. Simpson drain. The outlet of this drain is into the Town Line drain at the N. ¼ post of Sec. 5, Portsmouth township, T. 13 N., R. 6 E. The drainage area in said Sec. 5 includes the E. ½ of the N. E. ¼ of the N. W. ¼, the S. E. ¼ of the N. W. ¼, the N. E. ¼ of the S. W. ¼, the E. ½, the N. ½ of the S. E. ¼ of the S. W. ¼, the S. W. ¼ of the N. W. ¼ of the N. E. ¼, the W. ½ of the S. W. ¼ of the N. E. ¼, the W. ½ of the N. W. ¼ of the S. E. ¼, the W. ½ of the S. W. ¼ of the S. E. ¼.

100. Skelton creek. This drain has not been dug. The levels of the creek end on the line between Secs. 4 and 5, T. 14 N., R. 3 E. The outlet of the creek is in the S. W. ¼ of the N. W. ¼ of Sec. 1, Williams township, T. 14 N., R. 3 E. The drainage area in Williams township is as follows: In Sec. 2, the N. ½ of said Sec.; in Sec. 3, the N. ½, and the N. ½ of the N. ½ of the S. E. ¼; in Sec. 4, the N. ½, and the N. ½ of the S. ½; in Sec. 5, the N. E. ¼, the S. ½ of the N. W. ¼, the N. ½ of the S. E. ¼, the S. W. ¼; in Sec. 6, the S. E. ¼, the S. ½ of the S. W. ¼; in Sec. 7, the N. ½ of the N. E. ¼, the N. W. ¼. In Beaver township, T. 15 N., R. 3 E., in Sec. 33, the S. ½ of the S. ½; in Sec. 34, the S. ½ of the S. ½; in Sec. 35, the S. ½ of the S. W. ¼.

101. Sloat drain. This drain has its outlet into the No. 1 drain on the E. line of Sec. 31, Kawkawlin township, T. 15 N., R. 4 E. The drainage area in said Sec. 31 includes the S. ½ of the S. E. ¼ of the N. E. ¼, the S. E. ¼, the E. ½ of the S. W. ¼.

102. Smith drain. This ditch has its outlet into the Kerr drain on the N. ½ of the N. W. ¼ of the N. E. ¼ of Sec. 15, Kawkawlin township, T. 15 N., R. 4 E. The drainage area includes the N. W. ¼ of the N. E. ¼, the E. ½ of the N. W. ¼, the W. ½ of the N. W. ¼, in Sec. 15; in Sec. 16, the N. ½ of the N. E. ¼, the N. E. ¼ of the N. W. ¼; in Sec. 10, the S. E. ¼ of the S. W. ¼.

103. Smith Creek drain. This drain has its outlet into the north fork of the Kawkawlin river in the N. E. ¼ of the S. E. ¼ of Sec. 11, T. 15 N., R. 3 E. The drainage area includes the E. ½ of the N. E. ¼ of Sec. 11; in Sec. 2, the E. ½ of the S. E. ¼, the N. W. ¼ of the S. E. ¼, the N. E. ¼, the E. ½ of the N. W. ¼; in Sec. 1, the W. ½ of the S. W. ¼; in T. 16 N., R. 3 E., the W. ½ of Sec. 35, the W. ½ of the E. ½; in Sec. 34, the N. E. ¼; in Sec. 27, the S. E. ¼; in Sec. 26, the S. W. ¼ of the S. E. ¼, the S. W. ¼.

104. Squaconning, North Branch. This drain has its outlet at a point about 100 rods W. of the E. line of Sec. 3, T. 13 N., R. 4 E., and 33 feet N. of the N. E. line in said Sec. 3, running thence up stream following the natural water course. The outlet of the, drain into the Squaconning creek in the W. ½ of the S. E. ¼ of Sec. 2, 80 rods N. of the S. line of said section, T. 13 N., R. 4 E. The drainage tributary to this natural water course in said Sec. 2; the N. W. ¼ of the S. E. ¼, the N. ½ of the N. E. ¼ of the S. W. ¼, the N. ½ of the N. E. ¼ of the S. W. ¼, the S. W. ¼ of the N. W. ¼; in Sec. 3, the S. E. ¼ of the N. E. ¼, the N. E. ¼ of the N. E. ¼, the W. ½ of the N. E. ¼, the N. ½ of the S. E. ¼ of the N. W. ¼, the N. E. ¼ of the N. W. ¼, the W. ½ of the N. W. ¼; in Sec. 4, the N. E. ¼ of the N. E. ¼; in Sec. 34, T. 14 N., R. 4 E. the S. W. ¼ of the S. W. ¼; in Sec. 33, the S. ½, and the N. W. ¼; in Sec. 32, the S. ½, and the S. ½ of the N. E. ¼, the N. E. ¼ of the N. E. ¼; in Sec. 31, the S. E. ¼; in Sec. 6, T. 13 N., R. 4 E., the N. E. ¼.

106. Tobico drain. This drain was dug during the high water of May, 1884, when the lake extended to a point 30 rods W. of the N. ¼ post of Sec. 24, T. 15 N., R. 4 E. At the present time this area is occupied by a swamp to where the shore line now is. The outlet is into a swamp 30 rods W. of the N. ¼ post of Sec. 24. Drainage area includes in said Sec. 24, the N. ½ of the N. W. ¼; in Sec. 13, the W. ½ of the S. E. ¼ of the S. W. ¼, the S. W. ¼ of the S. W. ¼; in Sec. 14, the S. E. ¼ of the S. E. ¼; in Sec. 23, the N. E. ¼ of the N. E. ¼.

107. Town Line drain. Commencing at the W. bank of the Quanicassee river at the N. E. corner of Sec. 1, Merritt township, T. 13 N., R. 6 E., which is the outlet of this drain. Drainage area in said Sec. 1 includes the N. ½ of the N. W. ¼ of the N. E. ¼, the N. ½ of the N. W. ¼; in Sec. 2, the N. ½ of the N. ½; in Sec. 3, the W. ½ of the N. E. ¼ of the N. E. ¼, the N. W. ¼ of the N. E. ¼, the N. ½ of the N. W. ¼; in Sec. 4, the N. E. ¼ of the N. E. ¼, the E. and N. ½ of the N. W. ¼ of the N. E. ¼, the W. ½ of the N. E.

¼ of the N. W. ¼, the W. ½ of the N. W. ¼; in Sec. 5, the E. ½ of the N. E. ¼, the E. ½ of the N. W. ¼ of the N. E. ¼, the N. E. ¼ of the N. W. ¼, the W. ½ of the N. W. ¼; in Sec. 6, the N. E. ¼, the N. W. ¼ of the S. E. ¼, the E. ½ of the N. W. ¼, the N. ½ of the N. W. ¼ of the N. W. ¼; in Sec. 1, T. 13 N., R. 5 E., the W. ½ of the N. E. ¼, the N. W. ¼; in Sec. 2, the N. E. ¼. In Sec. 36, Hampton township, T. 14 N., R. 6 E., the S. ½ of the S. E. ¼ of the S. E. ¼, the S. W. ¼ of the S. E. ¼, the S. W. ¼; in Sec. 35, the S. ½; in Sec. 34, the E. ½ of the S. E. ¼, the E. ½ of the W. ½ of the S. E. ¼, the S. ½ of the S. E. ¼ of the S. W. ¼, the S. W. ¼ of the S. W. ¼; in Sec. 33, the S. E. ¼ of the S. E. ¼, the S. ½ of the S. W. ¼ of the S. E. ¼, the S. W. ¼ of the S. W. ¼; in Sec. 32, the S. E. ¼ of the S. E. ¼, the S. ½ of the S. W. ¼ of the S. E. ¼, the S. W. ¼ of the S. W. ¼; in Sec. 31, the S. ½ of the S. E. ¼ of the S. E. ¼, the S. W. ¼ of the S. E. ¼, the S. E. ¼ of the S. W. ¼, the S. ½ of the S. W. ¼ of the S. W. ¼; in Sec. 36, T. 14 N., R. 5 E., the S. ½ of the S. ½ of the S. E. ¼, the S. ½ of the S. E. ¼ of the S. W. ¼, the S. W. ¼ of the S. W. ¼; in Sec. 35, the S. ½ of the S. E. ¼ of the S. E. ¼, the S. W. ¼ of the S. E. ¼, the S. W. ¼.

108. Treiber drain. At the N. W corner of Sec. 31, Merritt township, T. 13 N., R. 6 E., this drain has its outlet into the Saginaw County drain, which I believe empties into the Cheboyganing creek on the N. line of Sec. 34, T. 13 N., R. 5 E The N. outlet of the drain is at the E. ¼ post of Sec. 18, T. 13 N., R. 6 E., where it runs into the Quanicassee river. The drainage area in Sec. 31 is the N. ½ of the N. W. ¼, the N. W. ¼ of the N. E. ¼, the N. ½ of the N. E. ¼ of the N. E. ¼; in Sec. 30, the S. ½, the S. E. ¼ of the N. E. ¼, the S. and E. ½ of the N. E. ¼ of the N. E. ¼; in Sec. 19, the E. ½ of the S. E. ¼ of the S. E. ¼, the N. E. ¼ of the S. E. ¼, the S. E. ¼ of the N. E. ¼, the S. and E. ½ of the N. E. ¼ of the N. E. ¼, in Sec. 18, the E. ½ of the S. E. ¼ of the S. E. ¼, the N. E. ¼ of the S. E. ¼; in Sec. 29, the W. ½ of the S. W. ¼ of the S. W. ¼, the N. W. ¼ of the S. W. ¼, the N. W. ¼; in Sec. 20, the S. W. ¼, the S. ½ of the N. W. ¼; in Sec. 17, the N. W. ¼ of the S. W. ¼.

109. Tromble drain. This drain empties into the Saginaw river on the N. line of Sec. 16, T. 13 N., R. 5 E. The drainage area is as follows: The S. ½ of the S. E. ¼ of Sec. 9; in Sec. 10, the S. ½ and the S. ½ of the N. W. ¼; in Sec. 11, the W. ½ of the S. W. ¼ and the W. ½ of the N. W. ¼, the S. E. ¼ of the S. W. ¼, the S. and E. ½ of the S. W. ¼ of the S. E. ¼, the E. ½ of the S. E. ¼; in Sec. 12, the S. W. ¼, and the S. W. ¼ of the S. E. ¼; in Sec. 13, the N. ½ of the N. W. ¼ of the N. E. ¼, the N. ½ of the N. W. ¼; in Sec. 14, the N. ½ of the N. ½; in Sec. 15, the N. ½ of the N. ½.

110. VanAlstine drain. Empties into the Indian Town drain 40 rods S. of the N. E. corner of Sec. 6, T. 14 N., R. 5 E. The drainage area includes in Sec. 31 the S. and E. ½ of the S. E. ¼ of the S. E. ¼, the N. ½ of the S. E. ¼, the N. E. ¼ of the S. W. ¼, the N. ½ of the N. W. ¼ of the S. W. ¼, the S. ½ of the N. ½, the N. E. ¼ of the N. E. ¼; in Sec. 32, T. 15 N., R. 5 E., the W. ½ of the W. ½.

111. Vigor drain. This drain empties into the Cheboyganing on the S. line of Sec. 36, 74 chains W. of the S. E. corner T. 13 N., R. 5 E. The drainage area in Bay county includes, in Sec. 31, the S. ½ of the S. ½; in Sec. 32, the S. ½; in Sec. 33, the S. W. ¼; in Sec. 34, the S. E. ¼ of the S. W. ¼, the S. ½ of the S. W. ¼ of the S. W. ¼, the S. and E. ½ of the S. W. ¼ of the S. E. ¼ of the S. E. ¼, the S. ½ of the N. E. ¼ of the S. E. ¼; in Sec. 35, the S. ½ of the S. W. ¼, the S. and E. ½ of the S. W. ¼ of the S. E. ¼, the S. E. ¼ of the S. E. ¼; in Sec. 36, the S. ½ of the S. W. ¼, the S. and E. ½ of the S. W. ¼ of the S. E. ¼, the S. E. ¼ of the S E. ¼.

112. Walther drain. This empties into Saginaw Bay on the N. and S. ¼ line of Sec. 7, T. 14 N., R. 6 E. In said Sec. 7 the drainage area includes the S. ½ of the S. W. ¼ of the N. E. ¼, the S. ½ of the N. W. fractional ¼, the N. W. ¼ of the S. E. ¼, the N. fractional ½ of the S. W. ¼, the S. W. ¼ of the S. E. ¼, the S. fractional ½ of the S. W. ¼; in Sec. 18, the N. W. ¼ of the N. E. ¼ and the N. fractional ½ of the N. W. ¼.

113. Wanderwilt drain. This drain has its outlet at the N. ¼ post of Sec. 36., T. 14 N., R. 5 E. The drainage area in said Sec. 36 includes the E. and S. ½ of the N. E. ¼ of the N. W. ¼, the S. E. ¼ of the N. W. ¼, the N. E. ¼ of the S. W. ¼, the N. and E. ½ of the S. W. ¼ of the S. E. ¼, the N. W. ¼ of the S. E. ¼, the S. W. ¼ of the N. E. ¼, the S. and W. ½ of the N. W. ¼ of the N. E. ¼.

114. Warner drain. This drain empties into the Saginaw Bay at the N. E. corner of Sec. 25, Hampton township, T. 14 N., R. 6 E. The drainage area in said Sec. 25 includes the N. ½ of the N. W. ¼ of the N. E. ¼, the N. W. ¼; in Sec. 26, the N. ½ of the N. E. ¼, the N. ½ of the N. W. ¼; in Sec. 23, the S. ½ of the S. ½; in Sec. 24, the S. W. ¼ of the S. W. ¼, the S. ½ of the S. E. ¼ of the S. W. ¼, the S. ½ of the S. W. ¼ of the S. E. ¼.

116. Watt drain. This drain empties into the Brown drain at the N. ¼ post of Sec. 30, Merritt township, T. 13 N., R. 6 E. The drainage area includes the W. and S. ½ of the N. W. ¼ of the N. E. ¼, the S. W. ¼ of the N. E. ¼, the N. ½ of the N. W. ¼ of the S. E. ¼, the N. ½ of the N. E. ¼ of the S. W. ¼, the S. E. ¼ of the N. W. ¼, the E. ½ of the N. E. ¼ of the N. W. ¼.

117. Webster drain. This drain has its outlet into a road ditch on the E. line of Sec.

4, Williams township, T. 14 N., R. 3 E. Drainage area the S. E. ¼ of said Sec. 4, the E. ½ of the S. W. ¼ of the same section.

118. Williams drain. This drain has its outlet into the Chute Creek drain in the S. E. ¼ of the N. E. ¼ of Sec. 4, T. 16 N., R. 4 E. Drainage area in said Sec. 4, the N. W. ¼ of the N. E. ¼, the N. ½ of the S. W. ¼ of the N. E. ¼, the N. W. ¼; in Sec. 5, the N. E. ¼.

119. Williams and Tittabawassee drain. This drain has its outlet into the Culver Creek drain of which it is a continuation. Commencing at a point 2.6 chains N. of the S. E. corner of Sec. 25, Williams township, T. 14 N., R. 3 E. The drainage area in said Sec. 25 includes the S. E. ¼ of the S. E. ¼; in Sec. 36, the N. E. ¼, the N. E. ¼ of the N. W. ¼, the S. ½ of the N. W. ¼, the S. W. ¼; in Sec. 35, the S. ½ of the S. ½; in Sec. 34, the S. ½ of the S. ½ of the S. E. ¼, the S. ½ of the S. ½ of the S. W. ¼. The drainage area in Saginaw county is not here given.

120. Young drain. This drain empties into the Center Avenue dredge cut on the E. line of Sec. 27, Hampton township, T. 14 N., R. 6 E. Elevation here is 584.3 A. T. The drainage area in said Sec. 27 includes the E. ½ of the S. E. ¼, the S. W. ¼ of the S. E. ¼, the S. ½ of the S. W. ¼; in Sec. 34, the N. ½ of the N. E. ¼, the W. ½ of the N. E. ¼, of the N. W. ¼, the N. W. ¼ of the N. W. ¼; in Sec. 28, the S. ½ of the S. ½; in Sec. 29, the S. ½ of the S. ½; in Sec. 30, the S. ½ of the S. ½; in Sec. 25, T. 14 N., R. 5 E., the S. ½ of the S. ½; in Sec. 26, the S. E. ¼ of the S. E. ¼; in Sec. 33, T. 14 N., R. 6 E., the E. ½ of the N. E. ¼, the N. W. ¼ of the N. E. ¼, the N. ½ of the N. E. ¼ of the N. W. ¼, and the E. and N. ½ of the N. W. ¼ of the N. W. ¼; in Sec. 32, the W. ½ of the N. E. ¼ of the N. E. ¼, the E. ½ of the N. W. ¼ of the N. E. ¼, the N. and W. ½ of the N. E. ¼ of the N. W. ¼, the E. and N. ½ of the N. W. ¼ of the N. W. ¼; in Sec. 31, the N. ½ of the N. E. ¼ of the N. E. ¼, the N. W. ¼ of the N. E. ¼, the N. E. ¼ of the N. W. ¼, the N. ½ of the N. W. fractional ¼ of the N. W. fractional ¼; in Sec. 36, the N. and W. ½ of the N. E. ¼ of the N. E. ¼, the E. and N. ½ of the N. W. ¼ of the N. E. ¼, the N. and W. ½ of the N. E. ¼ of the N. W. ¼, the E. and N. ½ of the N. W. ¼ of the N. W. ¼. Sec. 36 is in T. 14 N., R. 5 E.; in Sec. 35, same township and range, the N. and W. ½ of the N. E. ¼ of the N. E. ¼, the N. W. ¼ of the N. E. ¼, the N. W. ¼.

CHAPTER VI.

ECONOMIC GEOLOGY, ESPECIALLY WATER SUPPLY.

1. *Introduction.*

In chapters II, III and IV we had occasion to review the geology of the underlying sedimentary formations of Bay county, the coal measures with its associated beds of shale and iron carbonate, and finally in chapter IV the soil and sub-soil formations. It is the purpose of this chapter to draw more particular attention to the raw products associated with the drift and underlying consolidated formations which were described there.

2. *Salt Industry.*

In Volume III, Appendix B, of the series of quarto reports of the Michigan Geological Survey, Dr. S. S. Garrigues, for several years State Salt Inspector, contributed a report on the production of salt in the Lower Peninsula. This was printed in 1876. In the year 1895, Lucius L. Hubbard, State Geologist, wrote an introduction on the "Origin of Salt, Gypsum and Petroleum," which appeared in Volume V, Part 2, of the same series of state reports. For information concerning the chemistry of salt and a general description of the subject, the reader is referred to the preceding reports. The earliest extensive treatment of the salt manufacture in the Saginaw valley was by Dr. H. C. Hahn in the "Berg-und-Huettenmaennische Zeitung" for 1867, in a series of articles running through the year from page 97 to page 339. Dr. Hahn was located in the New York and Saginaw works in Saginaw county, and it is intended to give a full account of his tests in the Saginaw county report.

At Bay City brines have been utilized from three sandstone horizons, namely: The Parma sandstone at a depth of about 600 feet; the Marshall sandstone at about 900 feet, but varying considerably in elevation north and south of the Middle Ground; and the Berea Grit at a depth in the neighborhood of 2,100 feet. At the Atlantic Mill, and in the deep well at South Bay City, brines from the Berea reached the surface from an average depth of 2,200 feet. A third well was put down on the west side near 28th street. Unfortunately the deep well at South Bay City was not put down into the underlying Salina beds of the Monroe formation, which contain beds of rock salt throughout the greater portion of Lower Michigan. Brines from the Marshall or Berea are remarkably free from calcium sulphates and not likely to cake. On the other hand, rock salt brines contain more lime, especially the sulphate, which produces caking. This is again counterbalanced by the fact that the natural brines contain earthy chlorides so that a large amount of the bittern must be thrown away. In Bay City a valuable disinfectant is said to be made from this bittern. An analysis of this as contained in one gallon of 231 cubic inches, in grains, was given me by Mr. E. S. Fitch of Bay City.

Alumina sulphate	33.6882 grains
Alumina chloride	1693.8770 grains
Magnesium bromide	1169.1127 grains
Magnesium chloride	475.4984 grains
Sodium chloride	537.4984 grains
Calcium chloride	1372.5135 grains

Among the most important by-products in the manufacture of salt are soda, potash and bromine, the latter of which is the base of the best photograph paper. The soda-ash business is one of the foundation stones of chemical industries.

We herewith present analyses of the three principal brines from the Parma, Marshall and Berea horizons, as follows:

Parma, Gilmore well, Bay City, Michigan. Depth of well, 505 feet. Brine 65° by salinometer.

Sulphate of lime (gypsum)	0.3961
Chloride of calcium	0.5302
Chloride of magnesium	.4115
Chloride of sodium (salt)	15.2674
Saline matter	16.6052
Water	83.3948
	100.0000

South Bay City, Deep Well, Marshall, flow at 900 feet. Specific gravity 1.186, 295 total solids per liter.

$CaSO_4$	0.07 per 100 grams
$CaCl_2$	3.4
$MgCl_2$	1.35
K Na	19.9

South Bay City, Berea, Analysis of flow at 2,200 feet by Dr. Zahorski of the North American Chemical Co.

Na Cl	186.19 grams per liter
Ca Cl	110.60
$MgCl_2$	33.47
$CaSO_4$	0.30
Fe_2O_3	1.14

3. *Shales and Fire Clay.*

In Volume VIII, Part 1, H. Ries has partially described the clays and shales of Michigan, with an account of their properties and uses. To obtain a perspective of this subject, and a proper idea of the relationship of the shale beds of Bay county to that of the rest of the state, the reader is referred to that report.

In connection with the description of the coal formation in Bay county, we had occasion to describe certain beds of fire clay or shale, but generally identified as slate by the drillers, to whom we are indebted for our records. These shale beds are almost invariably found associated with beds of coal, but also occur where the coal is wanting.

There are also massive beds of shale in the Coldwater formation, which are

found at a depth of from 1,200 to 2,000 feet. Where these beds outcrop at the surface, as in Branch county, they are utilized in the manufacture of Portland cement. Outcrops of this formation are also found on the Lake Huron shore in the southeastern part of Huron county. On account of the convenience of water transportation, the time is probably not far distant when this shale will be assembled with limestone or marl, brought down from the north to Bay City, and made into Portland cement, brick, and other products which depend upon clay and shale for raw material. These Coldwater shales probably run too low in siliceous matter to be burnt for road metal. In such manufactures, the assembling point is determined by transportation, fuel and accessibility to the market. In these regards Bay City is rather a strategic point. As we shall see, however, shale beds more or less suitable in quality, are found with workable beds of coal in Bay county.

Without taking into consideration the marl or limestone which forms approximately 65% of the Portland cement mixture, there are certain desirable qualities which it is necessary that the clay should possess for utilization in the cement business. Prof. Delos Fall informs me that an ideal clay for such purposes should contain 60% of the oxide of Silicon (SiO_2), 17% of Al_2O_3 and 3% of iron oxide. In other words the oxides of iron and alumina form $\frac{1}{3}$ of the entire amount of SiO_2[1]. Clays should contain very little free sand, iron oxide, or organic matter. The silica must be combined and not free. It should have a tendency to gelatinize when treated with acids. The presence of over 2% of magnesium oxide (?) or sulphuric acid in the form of calcium sulphate, is deleterious on account of the tendency to partially dissolve and thus lead to the final disintegration of the proposed structure.[2]

In the above remarks, we only had occasion to notice the chemical properties of clay in regard to their adaptation to the cement business. In Volume VIII, Part 1, H. Ries has described the properties of clay more particularly in reference to their use for brick, tiling, crockeryware, and other allied industries. While the properties which render clay and shale valuable for cement purposes are largely of a chemical nature, their use for other purposes depends not only on such properties, but also on certain physical tests such as slaking, plasticity, behavior under heat, shrinkage in drying and burning, color, and tensile strength.[3] Just as the chemical tests are more important in the cement business, so are the physical properties more important for the other purposes already outlined. For further information regarding these properties, the reader is referred to the above report.

At the mine of the Central Coal Mining Co., and at several other localities in Bay county, Mr. Ries examined and reported on beds of shale which underlies the Upper Verne seam there:

"This underlying clay at the Central Co. is quite homogeneous, and resembles somewhat that found at the Standard shaft near Saginaw (an earlier formation), but is much softer, being easily cut with the blade of a knife. It is stated that this clay was at one time tried for the manufacture of bricks at Saginaw and gave good results."

"Unlike most of the other shales found with the coals in this region, it slakes in water though slowly. It has a somewhat sandy appearance, and contains numerous small mica scales."

[1]The amount of silica can run somewhat higher if the ratio holds. Also the relative amount of iron oxide and alumina can vary together, if the total equals $\frac{1}{3}$ the amount of silica.
[2]Delos Fall, Michigan Geological Survey, Volume VIII, part 3, p. 344.
[3]*Michigan Geological* Survey, Volume VIII, part 1, p. 2.

"It took 19% of water to work it up to a lean but not granular mass, whose air shrinkage was 5%."

"The tensile strength of the air dried briquettes was from 50 to 60 pounds per square inch, and the soluble salt contents, 3%."

"In burning at cone 05 (1922° F.), the total shrinkage was 6%, but incipient fusion was not attained until cone 1 (temp. 2102°), with a total shrinkage of 7%, the color of the bricklet being cream." At cone 4 (2210° F.) the shrinkage was 9% and the color of the brick the same. Vitrification took place at 5 (2246°), and above this the clay burned to a grayish color, beginning to show signs of viscosity on the part of the larger ferruginious patches at cone 8 (2354°). The brick as a whole did not fail until cone 11 (2462°)."

At the mine of the Michigan Coal & Mining Co,. situated a short distance northwest of the Central Coal and Mining Co., and west of Salzburg, the upper shale under the coal (Lower (?) Verne), forms a layer two to three feet thick. It grades downward into a bluish-black shale.

"The under shale resembles somewhat that found at the Central Co's shaft. While the two types found under the coal both appear hard when dry, still they differ in plasticity, as already noted, when freshly mined, and this difference also shows itself in their further physical behavior."

"The upper part of the under clay behaves as follows: Water required to temper, 25%; air shrinkage of bricklets, 6%; tensile strength of air dried briquettes, 150 to 175 pounds per square inch; incipient fusion reached at cone 05 (1922°), with total shrinkage of 9%, vitrification at cone 1(2102° F.) and viscosity at 5 (2246°). Soluble salts 2%."

"The bottom layer, on the other hand, does not slake as readily as the preceding one. It shows no mica nor pyrite. In mixing it up only 17% of the water was required, and the resulting mass was granular and lean; it could be dried rapidly without cracking. The air shrinkage was 4%, and the tensile strength of the air dried briquettes ranged from 55 to 60 pounds per square inch. The soluble salts were 7%. The clay burns red at cone 06 (1850° F.) and vitrified at 2 (2138°),"

The shaft of the Wenona Coal Co's. mine terminates in the Upper Verne seam, and is underlain by light colored shale, and overlain by black fissle shale (the miners' slate). The thickness of the upper shale is said to vary from two to 10 feet.

"A sample of this material (undershale) was tested with the following results: It gave no effervescence with hydrochloric acid, and showed little or no pyrite, but scales of mica were not uncommon in it. When thrown into water it slaked little or none."

"In working it up, 18% of the water was required, giving a mass of low plasticity, whose air drying could be carried on rapidly, and was accompanied by 3½% of shrinkage."

"The tensile strength of the air dried briquettes was also low, amounting to an average of 55 pounds. The soluble salts were .6%."

"In burning, incipient fusion took place at cone 2 (2138°), with a shrinkage of but 4%, vitrification at 6 (2282°), and viscosity at 8 (2354). The shale burned red."

This over shale is to be compared with that first described as underlying the same seam of coal at the Central Coal Co's. shaft west of Salzburg.

"At the shaft of the Monitor Coal Co., the overlying shale is similar to that at the Wenona Coal Co's. shaft, but contains more bituminous matter." The two localities are on the some geological horizon, i. e., the Upper Verne

coal. The fire clay at the Monitor Coal Co's. shaft, now abandoned, but worked from the south in the entries from Bay No. 2 mine, is said to average 8 to 10 feet in thickness.

"A carload of these two shales was sent to Saginaw some time ago for testing, and found to yield very favorable results."

As will be noticed by referring to the chapter on coal, almost all the mines now running in Bay county are in the Upper Verne seam. We should consequently expect the above determinations to hold essentially for most of the mines now in operation. An exception to this is to be noted in the sample from the Michigan Coal and Mining Co's. shaft in the Lower Verne seam, now reached in three shaft holes in Bay county.

The following analyses by A. N. Clark are respectively from the shale under the Upper Verne coal at the Wenona mine, and for the upper part of the under clay in the mine of the Michigan Coal and Mining Co. of the Lower Verne (?) seam.

Silica, SiO_2	52.45	57.0
Alumina, Al_2O_3	23.27	20.02
Iron as Fe_2O_3	7.93	8.18
Lime as $CaCO_3$	1.82	0.71
Mg. as $MgCO_3$	1.06	1.47
Alkalies as K_2O	4.37	2.76
Difference largely H_2O and organic	9.10	9.76
	100.00	100.00
Ferrous iron as FeO	1.57	1.47

I am indebted to Mr. A. C. Lane for the following description of the brick plant of the Michigan Vitrified Brick Co.

"The new brick plant is right by the old one at the Valley Coal Co. on Dutch creek (Squaconing creek). They expect to make fire brick and paving brick. The section underneath the coal shows four and a half feet of fire clay and six feet of shale. They use half and half for paving brick."

"They now have two of the older kilns running of the E. U. Daley (?) pattern. The shale goes first to a dry grinder, then to a Berg press, dry process. They are giving 80 tons pressure, and the capacity is 20,000 bricks per day. They have two down draft kilns, one circular and one square."

"This is the present plant, and the fire brick which they are now making they are planning to use in their own kilns. For the clay mining they pay 20 cents a ton. In Ohio 18-20 cents is said to be paid."

"The new plant will, after the shale has been through the dry grinder, take it to a Bonnont No. 4 pug mill and die having a capacity of from 50,000 to 75,000 per day. Automatically the square stream of clay is forced through the die and goes on to the table where it is cut off by wires, side cut. Then it passes on to the represser, then into the drying tunnels 126 feet long, which it slides through on cars still by gravity, with a slope of one inch in seven feet. It takes from 24 to 48 hours to go through. These are fed by waste heat, the air fed to the fan can be heated by some 9,000 feet of radiation. There are sub-tunnels for the last 40 or 50 feet through which the air is fed in.

"Then the brick is automatically conveyed to 90-foot long kilns. Five of them cost $5,000 each, and the total cost of the entire plant is $150,000.

The tunnels, etc., are not of as large capacity as the Bonnont mill. So there may be enlargement soon."

For the following shale and clay analyses made by Lathbury & Spackman, I am indebted to Mr. U. R. Loranger of the Hecla Portland Cement and Coal Co. plant of Bay City. Unfortunately the amount of sulphuric anhydride is not stated by them.

The following shale analysis is from coal test hole record number 85. I believe that it is from the shale underlying the Lower Verne in the N. W. ¼ of the S. E. ¼ of section 2, T. 13 N., R. 4 E.

Silica, SiO_2	65.24%
Alumina, iron oxide, Fe_2O_3, Al_2O_3	23.56
Lime, Ca O	None
Magnesia, Mg O	1.11
Loss on ignition	6.72
	96.63

For cement purposes this shale is to be recommended for its low content of lime and magnesia. While the amounts of oxides of iron and alumina is about 1.8% too high for the amount of silica content, the relative amounts hold fairly well for a cement shale.

This analysis is from a surface clay from the Michigan Clay Co. in the S. E. ¼ of section 7, T. 13 N., R. 5 E.

Silica, SiO_2	44.60%
Iron and alumina, Fe_2O_3, Al_2O_3	13.11
Lime, Ca O	11.47
Magnesia, Mg O	7.09
Loss on ignition	17.91
	94.18

Whether the sand is free or combined in this material, is not stated. The oxides of lime and magnesia, however, are altogether too high for this cement purpose. It is also probable that the lime content would unfit it for making brick on account of its tendency to burst and crack.

A similar analysis is from the Williams Clay Co. just north of this last locality.

Silica, SiO_2	40.76%
Iron, Alumina, Fe_2O_3, Al_2O_3	15.39
Lime, Ca	12.83
Magnesia, Mg O	6.83
Loss on ignition	18.35
	94.16

The following analysis is probably from one of the coal shafts in section 25 of Monitor township. It is comparable to the analysis made by A. N. Clark of the shale below the Upper Verne, in the same vicinity.

Silica, SiO_2	51.40%
Alumina, iron oxide, Al_2O_3, Fe_2O_3	29.30
Lime, Ca O	.15
Magnesia, Mg O	2.23
Sulphur	0.79
Loss on ignition	11.84

For cement purposes the amount of silicate is too low, and that of the oxides of iron and alumina too high. The content of magnesia is also greater than is desirable for such purposes. This shale, however, is very probably on the same horizon as the shale that is being used at the Valley Mine for the manufacture of vitrified brick.

The two following analyses are probably associated with the Lower Verne coal in the Hecla shaft (?) in section 2 of Frankenlust township.

Silica, SiO_2	61.13%
Alumina, iron oxide, Al_2O_3, Fe_2O_3	26.90
Lime, Ca O	.12
Magnesia, Mg O	.96
Loss on ignition	6.47
	95.58

Except for the too high amount of oxides of iron and alumina, the shale given above would be adapted for cement manufacture. It would be better to have the percentage of iron and alumina stated separately. This is a light shale probably underlying the Lower Verne coal.

The following is a dark shale from the same (?) locality.

Silica, SiO_2	54.93%
Alumina, iron oxide, Al_2O_3, Fe_2O_3	31.43
Lime, Ca O	.22
Magnesia, Mg O	1.58
	88.16

Prof. F. S. Kedzie of the Michigan Agricultural College made the following analysis of a shale bed on property leased by the Hecla Portland Cement and Coal Co. It is very nearly an ideal material for this purpose except for the rather high percentage of sulphuric anhydride and iron oxide.

Silica, SiO_2	58.95%
Alumina, Al_2O_3	14.45
Iron oxide, Fe_2O_3	7.60
Lime, Ca O	2.94
Magnesia, Mg O	.86
Sulphuric anhydride, SO_3	1.73
K_2O	2.54
Water of combination	7.50
Organic matter and loss	3.43
	100.00

4. *Road Metal.*

The black shale overlying the Upper Verne coal has been burnt, and used for road metal in Frankenlust township. I am told that the result is quite satisfactory. The large amount of this material on the dumps of the different Bay county mines could very probably be used to advantage in this way. If a mill is ever established for this purpose, I believe that it would be advantageous to have the material crushed to about the size of coarse gravel, before burning. Similar use of this black shale has been made at

Jackson. At St. Charles the shale overlying the Saginaw coal has been put on the road without burning, with not so good results.

Other road metal material has been obtained from the surface deposits of Bay county. In this way the Kawkawlin stone road has been improved near its intersection with the Railroad drain in the northern part of Kawkawlin township. The material was obtained from beach washings on the shore of Saginaw bay near Linwood.

A gravel-sand deposit crosses the north line of section 6 Kawkawlin township, meandering north and south near the house of August Gregoire, in section 31 of Fraser. This material drains and packs well, but would very likely be further improved by screening. For local purposes it might very well be utilized, as for instance on the road leading west from Linwood.

In the chapter on soils and sub-soils, attention was directed to another sand and gravel beach running north, a short distance east of Bently. I believe that this deposit could be used by the Bay County Stone Road Commission in their prospective improvements in Pinconning, Mt. Forest and Gibson townships, if not farther south. Gravel deposits also occur one mile north of Gladwin, near that branch of the Michigan Central running west from Pinconning, and through Mt. Forest township.

With the utilization of the above mentioned surface deposits in the northern part of the county, and other road metal to be obtained from the mines in the latitude of Bay City, the development of the county stone roads could probably be more economically and expeditiously carried on than heretofore. Crushed erratics or cobbles also make a very excellent road material which could be used to a limited extent.

An ideal road metal is found in the trap rock of Mt. Bohemia near Lac La Belle in Keweenaw county. The rock is hard with good cementing qualities and has but very little dust. The transporting facilities by water being favorable, the time may come when it will be found profitable to use on our Bay county roads, even if it could not now be used to advantage. The U. S. Department of Agriculture is engaged in making tests of road material gratis. This department has published Bulletin No. 79, on "The Testing of Road Materials," which may be obtained on application.

The specific gravity and weight per cubic foot are coordinates. I presume these factors are given in order to determine the weight as relative to the comparative efficiency of the rock, as determined by the hardness, toughness, and cementing value of the material used. Where road metal is shipped considerable distances, this factor would enter into consideration as compared with the results obtained, as shown by the per cent of wear. The latter factor is again the visible result of the three principal physical characters, hardness, toughness and cementing value.

The absorption test is not intended to give the porosity, but merely the number of pounds of water that is absorbed by a cubic foot of rock in 96 hours. This factor is important in connection with the effect of freezing on road materials. "It is very doubtful whether the effects of freezing is injurious to road materials that absorb water even in considerable amounts, but at all events it is probably very small when compared with the destruction wrought by this same agency on the road bed as a whole. One hundred volumes of water expand on freezing to 109 volumes of ice. If expansion is prevented, the pressure developed on cooling the water 1° below its normal freezing point, is 144 tons per square foot. When we examine the subject closely it becomes apparent that the action of frost on road mate-

rials is not so great as it at first seems."[1] A table is given showing the percentage of water absorbed by the more important road materials.

Hardness is defined from the road makers' standpoint as "the resistance which a material offers to the displacement of its particles by friction. The measure of hardness will be, inversely, as the loss of the weight arising from the scouring by an abrasive agent."[2] This is determined by grinding specimens with sand of a standard size and quality.

By toughness is understood to mean the power possessed by a material to resist fracture under impact. It can be readily seen that toughness is an important property from the standpoint of the road builder.[3]

The cementing or binding power of a road material is the property possessed by rock dust, or other finely divided material found in nature, to act as a cement on the coarser fragments composing crushed stone or gravel roads. This property not only varies with different kinds of rocks, but also with those which are practically identical in classification and chemical composition. The impervious shell obtained by the use of a rock of high cementing value, gives the greatest protection to the foundation of a road. A good binding quality also lessens the amount of dust and mud. For further information on these important physical properties the reader is referred to the bulletin quoted above.

5. *Soils.*[4]

In our soil map the different types of soils have been shown as accurately as possible. Thus sandy soils are indicated by dots, and sand ridges by solid lines enclosed within such areas. Land composed of clay and clay loam have been felt unmarked. Muck land and its different varieties are indicated by symbols which are used to mark swamp land, which indeed it was originally. For further information concerning soil and sub-soil deposits, the reader is referred to chapter IV, and the map which has been prepared to accompany that chapter.

6. *Muck Land.*

In Bay county there are two principal types of this deposit; the first underlaid with clay, and the other with sand. Either type, if it be an acid muck, is not to be utilized unless properly treated. This treatment depends on the lack of conductivity of muck to heat and cold. While sandy soils show the frost extending down to a depth of four feet, a bed of muck was frozen to a depth of only eight inches. Therefore muck must be put on the ground in early winter, and scattered thinly over the ground surface in order to remove its acid properties. In Great Britain they resort to the process of "pairing and drying," cutting the surface into thin slices to dry it, and then burning the dried mass and scattering the ashes on the unburned portion.

"If swamp muck has sufficient drainage much of the potash, soda, lime, etc., will be carried off in the drainage water, and the ash of such muck will be proportionately poorer in these materials."

The addition of muck to clay lands makes them more open and friable. To get the best results, however, the system must be combined with thor-

[1] Bull. U. S. Dep't of Agriculture, No. 79, p. 12.
[2] Id. p. 7.
[3] Id. p. 8.
[4] The U. S. Dept. of Agriculture has published a soil map of a portion of Bay county.

ough drainage. In light sands the addition of muck prevents excessive drying of the soil. It also absorbs and holds manure, and prevents its waste in the soil.

Dark colored substances absorb more sunlight than those of a light color. The following table will show the result of the addition of muck to clay and sand in increasing the temperature of the ground.

	Tile clay.	Tile clay+ 12% muck.	Gain.	Sand.	Sand+ 12% muck.	Gain.
May	59.57°	61.25°	1.68	59.57	60.89	1.32
June	70.79	72.02	1.23	70.89	73.21	2.32
July	81.75	83.07	1.32	82.07	86.72	4.65
August	70.59	72.32	1.73	71.25	73.26	2.01
September	57.25	59.22	1.97	58.59	59.72	1.13
Average gain			1.59			2.29

These observations are the result of readings taken at 7 A. M. and at 2 and 9 P. M., and extending from May 1st to October 1st.[1] The increased temperature given the soil has its obvious benefits in germinating and accelerating the growth of crops. Inasmuch as muck land has a greater development in this region than further south, the difference in latitude can in a measure be counterbalanced by the use of this material wherever it is available. Muck is also valuable on account of its power to absorb and retain ammonia. As Dr. Kedzie has remarked, it is a storehouse of fixed nitrogen and ammonia.

7. *Sandy Soils.*

This soil formation in Bay county is very often so thin as merely to aid in making the clay subsoil more tillable. The sandy and gravelly soils of Gibson township produce famous crops of potatoes, clover and hay. In other localities it produces fine crops of garden truck, it being a not uncommon sight in Bay and Saginaw counties to have a garden located on top of a sand ridge, and adjacent to the home where the drainage is good.

In Bulletin 198 of the Michigan Experiment station the cultivation of sand lucerene is advocated. This plant is allied to the alfalfa of the southwest, and is to be recommended on account of its adaptability to resist droughts. After the first year it will yield four crops of hay annually, the amount varying from 5,917 to 6,800 pounds to the acre at the State Agricultural College. I believe, however, that the sand and gravel soils of glacial origin there, may prove rather different than the lake sands of Bay county.

Amber cane has grown on sandy soil with greater or less success. While it is more capable of resisting drought than corn, the short season is rather against its complete development. The stalk is said to make very fair fodder.

8. *Clay Soils.*

The clay lands of Bay county do not need to call for any very extended notice here. In the cultivation of sugar beets it has been shown to be highly adapted. Oats, wheat, barley, corn and all the staple crops of this latitude

[1]R. C. Kedzie, Michigan Board of Agriculture, 1875, p. 224.

flourish abundantly when supplied with the proper amount of rainfall. Drainage, however, is essential and I trust that chapter V on Physical Geography and Drainage, along with the contour map showing the location of drains, drainage areas as yet undeveloped, and contour lines giving the approximate mean slope of elevation, will be of value in the intelligent development of the drainage system of Bay county.

9. *Water Supply.*

This subject naturally resolves itself into several points, i. e., the area and depth of flowing wells, the depth to ground waters which do not reach the surface, the variation in depth to salt water, and the water supply for Bay and West Bay Cities. With the subject of artesian water my purpose here is to indicate as accurately as possible the depth of such wells, and such information as I was able to obtain relative to the geology of the same. Also all information obtained concerning the time wells have been in operation, the present and earlier rate and strength of flow, the character of the water, temperature and amount of flow. These remarks also apply in part to non-flowing wells.

The area of flowing wells, together with the districts formerly supplied with such water supplies, is shown on the map prepared to accompany this chapter. The present and prospective areas of artesian water is indicated by heavy stippling; the former extent being shown by lighter shading.

It will be observed in general, that the area of artesian waters is adjacent to the low lands lying west of Saginaw bay, and in the valley of the two forks of the Kawkawlin river. An exception to this, however, is in the narrow belt of flowing wells in the central part of Pinconning township. The greater part of the artesian water is from the drift.

In the northeastern part of Williams township the depth of flowing wells varies from 80 to 95 feet. The wells are found in sections 1, 2, 3, and 12, near the south fork of the Kawkawlin river, and Skelton creeks. The water is slightly salty and comes from gravel beds in the drift. The altitude to which water will rise ranges from about 590 to 620 feet A. T. This area formerly extended up the valley of Culver creek to the southeastward at an elevation of from 585 to 605 feet A. T. Quite recently, Mr. Theodore Archambeau while drilling for coal in the valley of the south fork of the Kawkawlin river, obtained a flow near the north line of section 10, T. 14 N., R. 4 E. This is the northeasterly continuation of the former Culver creek area.

Northward from Williams and in Beaver township, the area of artesian water is in a general way contiguous to the basin of the two forks of the Kawkawlin river, and a heavy drift-filled pre-glacial channel which has a southwesterly course across Beaver township. Beds of gravel of pre-Wisconsin drift age, deposited within the limits of this old channel in the Coal Measures, furnish the conditions necessary for the origin of flows here. The source of water is probably from the north and west. Where such beds are tapped, as in this relatively low surface area, flowing wells are obtained. The elevation of this area of flowing wells in Beaver is from about 600 to 625 feet A. T., rising to the northward. There are at least two and probably three water horizons in Beaver township, the upper water bearing gravel being at a depth of from 60 to 80 feet, and a lower at 110 feet. The same wells occasionally obtain flows at about 65 and 110 feet. Still deeper wells in this drift valley region have obtained flows at depths varying from

173 to 197 feet. The amount of flow does not seem to bear any relation to the depth. Two of the heaviest flowing wells have depths as widely different as 93 and 173 feet, the former in the S. W. ¼ of section 35 and the latter the Cherry well in the S. E. ¼ of section 16 of Beaver township.

In Kawkawlin township artesian waters have been obtained in rather limited areas adjacent to the upper reaches of the north fork of the Kawkawlin river, the northeastern and southwestern portions of the township. This latter area formerly opened out to the east, including the lower reaches of the north fork, down to its junction with the south fork of the Kawkawlin in Monitor township.

The very limited area near the corner of sections 28, 29, 32, and 33, is in a swale traversed by Number One drain. The elevation is from 605 to 610 feet A. T. The depth here to water is 82 feet from the gravel bed on the rock. An artesian well in the rock is found in the S. W. ¼ of the N. E. ¼ of section 21. The depth of the well is 175 feet; elevation of surface about 605 feet A. T.

The absence of flowing wells from the drift in the southeastern part of Kawkawlin, the northern part of Bangor townships and adjacent to the bay, is explained by the upward rise of the bed rock in that direction, and the almost entire absence of gravel bearing beds in the drift there. The artesian water seems to come from the northwest, and was thus ponded back by the bed rock and impervious clay.

Northward in Fraser township, artesian conditions appear comparatively simple, flows being obtained in gravel bearing beds probably just overlying the rock. The wells are restricted to the area within two miles of the Bay, with a tributary area extending about three miles up Michie creek, and thence west northwest past Tebo P. O., up the valley of Chute creek, to the west line of Fraser township. In the valley of Michie creek flows were formerly obtained some five and a half miles west of the bay. The area adjacent to the bay is from 580 to 590 feet A. T. The westward continuation of this area, up the valleys of Michie and Chute creeks, is below the 620-foot contour line. The depth varies from 28 to 30 feet as in the northern portion of the township, to as much as 75 feet along the road from Linwood, following very nearly the inequalities of rock elevation. In the northwest ¼ of section 18, is a well from the bed rock 128 feet deep, which has ceased to flow.

In Pinconning township the Chute creek area of artesian water is extended northward through the central portion of the township, flowing wells being obtained at depths variously ranging from 45 to 85 feet, and from 600 to 610 feet A. T. Apparently the water is obtained from gravel beds overlying the rock, in a similar geological position to those to the southward. East of the Algonquin beach line, following the state road, flows have occasionally been tapped at depths varying from 38 to 60 feet, and extending from the lake level up to the 610-foot contour line.

In Mt. Forest township there is a small area of artesian water, which probably has a considerably greater extent. This is in the S. E. ¼ of section 10, elevation from 650 to 665 feet A. T., where coal drilling operations were carried on for John Mansfield. Flows were obtained there at 90 feet, at the base of the drift, and in beds of sand rock in the Coal Measures. Prospectively the best area to test in future development, would be to the north and west, in the basin of the Saganing.

Taking the artesian waters as a whole, it will be noticed that almost all flows are obtained from gravel beds very frequently at the base of the drift

formation, or sometimes interstratified in the drift. Also that artesian water is often obtained in relatively depressed areas, and such areas are to a considerable extent determined by inequalities of the top of the bed rock, and the relatively low elevation of the gravel bearing beds in the drift formation.

While it is not possible to determine precisely the origin of the flows in the central and northern part of the county, it would not seem improbable that the elevated moraine covered with sand and gravel, traversing the western portion of Gibson township in a southwesterly direction, and thence southerly through Gladwin and Midland counties, furnish the catchment area. It is also thought that these beds of sand and gravel which hold the artesian water are interglacial, and were covered over by beds of hardpan and clay deposited during a later ice advance.[1]

Salt Waters. Depth to Brackish Water. Non-flowing Wells.

East of the Saginaw river the records of several wells in Hampton township show that water containing brine to a considerable extent, percolates upward in the Coal Measures to within about 125 feet of the surface. Above this depth, fresh water has been obtained at depths ranging from 30 to 80 feet.

In Merritt and Portsmouth townships, a number of well records indicate that wells in the drift having a depth of 80 feet, generally contain a small amount of saline matter. Shallow surface wells having a depth of from 15 to 20 feet, often contain an insufficient amount of water, beside being otherwise objectionable on account of the surface drainage, and organic matter which is apt to be washed in.

In section 14, Frankenlust township, a well obtained fresh water at a depth of 85 feet, but the same well after being extended to a depth of 130 feet became saline. For the central part of Frankenlust township the limit to which saline water percolates upward is about 100 feet. In general a fairly abundant water supply can be obtained at a depth of less than 50 feet.

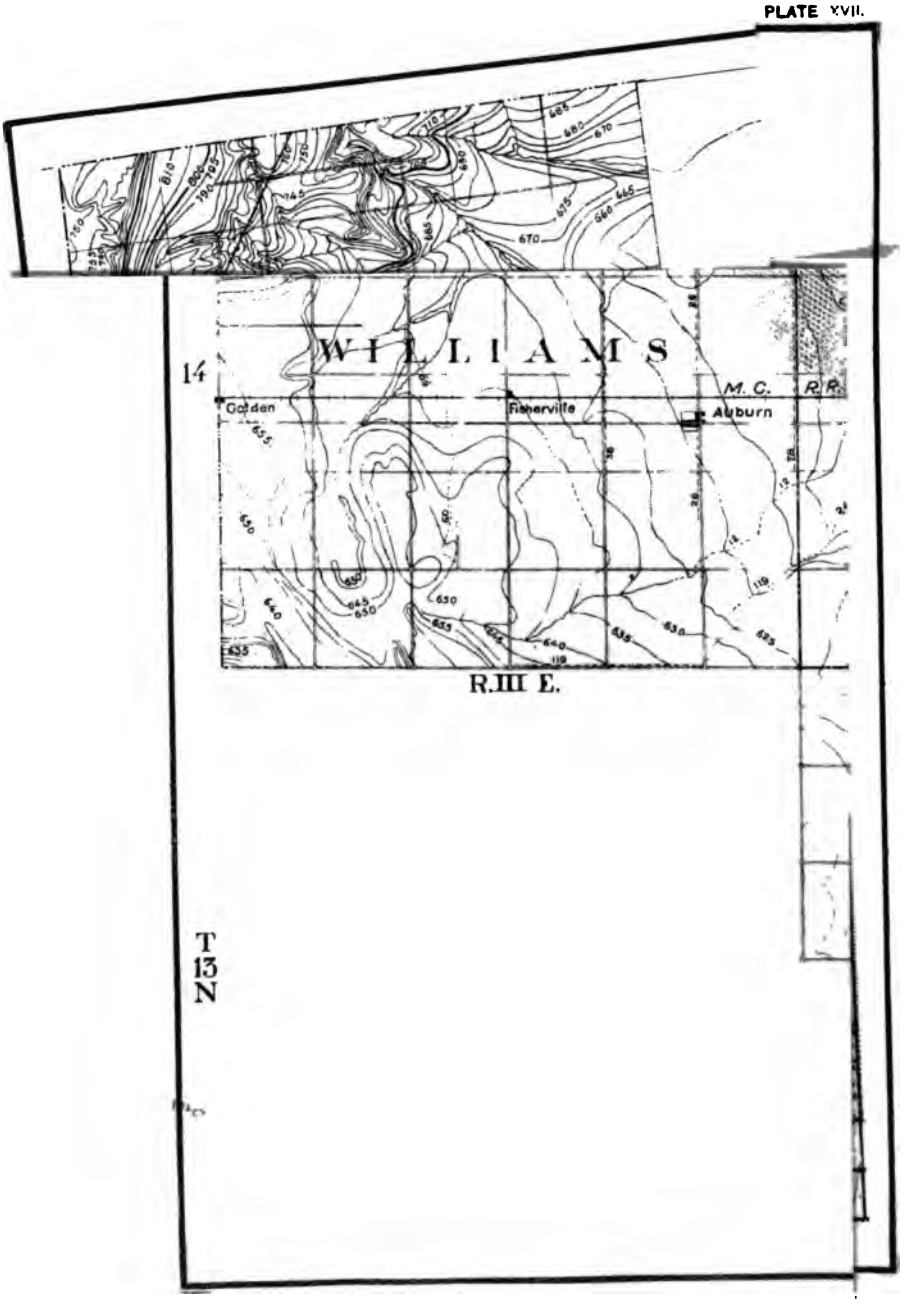
The first shaft of the Pittsburg Coal Company near Amelith, struck a bed of water bearing sand at a depth of about 90 feet. The great quantity which was pumped out at that time affected the water supply over two miles away, as for instance the well at the Michigan House, which was pumped dry.

In Bangor township an abundant water supply of good quality is generally obtained at a depth of less than 30 feet. Fresh water is obtained down to a depth of 80 feet in section 19, but at 115 feet brackish water was obtained in the adjoining section. Apparently the upper limit of percolation of brines in Bangor is not far from that obtained in Frankenlust to the south. Westward in Monitor township, the depth to brine increases to about the same depth as was observed for Hampton township; i. e., 125 feet, although wells in the drift are occasionally slightly brackish at about 90 feet. There appears to be no difficulty in obtaining water at lesser depths. Wells here obtain their supply in sand and gravel beds overlying the rock. There is a tendency for the sand to work in and clog up the pumps, necessitating occasional use of the sand pump.

In Williams township numerous wells in the eastern half of the township, and including the area of flowing wells already described, obtain their supply from the drift down to a depth of 220 feet, the latter depth being reached

1. Leverett, U. S. Geological Survey.

PLATE XVII.



in the deep well at Auburn. There is at Auburn, beginning at the top, 80 feet of clay, 138 feet of sand, and 2 feet of gravel above the rock (which is a shale of the Coal Measures). The gravel is water-bearing, but the overlying sand acts as a sponge, through which the water circulates without collecting in sufficient quantities to furnish a stable water supply. The drift filled preglacial drainage valley over which Auburn is located trends east and west, increasing in depth westward. Along its course, it would be well wherever possible, to obtain water at a depth of less than 80 feet. The process of drilling through sand is difficult and expensive, beside the added difficulty of keeping the casing free from sand.

In Beaver and Kawkawlin townships, and outside of the area of flowing wells already described, a sufficient supply of water is generally obtainable at a depth of less than 90 feet. However, in the northwestern part of Beaver, a well went down 130 feet to obtain water from the drift. A well noted by Mr. Shaw in section 28 of Kawkawlin, yields brackish water from the rock at a depth of 160 feet. The same well found fresh water at 105 feet, and also in the rock.

In the tier of sections formed by Fraser and Garfield townships, there are, outside of the area of flowing wells described in Fraser, water supplies at a depth of less than 112 feet, as at Crump P. O., with the exception of an area in the southwestern portion of Fraser township. Wells which have been sunk here to a depth of 80 or 90 feet have become dry. This may be due to the subsurface drainage, though the cause for failure is still an open question. It is probable that supplies may be obtained by deepening the wells into the underlying bed rock, say to a depth of about 125 feet. Wells in the western part of Garfield are generally shallow, and should be deepened as fast as opportunity permits.

Wells in Pinconning township have usually been able to obtain a sufficient supply at depths of less than 80 feet, but are occasionally deeper. In the southeast quarter of section 9, a well 200 feet deep obtained a good supply of water without any objectionable mineral properties.

In Mt. Forest township the wells are generally shallow, with the exception of a few in the southeastern portion of the township. These have a depth of from 90 to 145 feet, a deep one being at the school house in section 13. These deep wells seem to be free from any objectionable mineral matter.

In Gibson township most of the wells are shallow, and should be deepened as rapidly as possible, in order to insure a permanent and pure supply. In the morainal region in the western part of the township, Mr. Enoch Harvey drilled 100 feet without obtaining a sufficient water supply. At Bently, however, Mr. Wm. Hinman obtained an abundant amount of good water in a sandstone formation of the Coal Measures, at a depth of 160 feet. In order to obtain a permanent supply in the morainal region in the western third of Gibson township, it will probably be necessary to go to a depth similar to that of the Bently well.

The Fluctuations of Wells.

No precise data were obtained concerning the actual amount of water running from flowing wells, nor of the capacity of non-flowing wells. Shallow wells show a tendency to either become greatly lowered in summer, or else completely dry up. The Cherry well located in section 16 of Beaver township, was put down about 1880, having a depth of 173 feet. The flow

is constant and probably greater than that of any other flowing well in Bay county. The well of Wm. Peoples in section 32, of the same township, depth 74 feet, has ceased to flow.

Fraser township has a well 28 feet deep in section 2, put down in 1898, which had a steady flow in 1900. However, another well in section 6 of the same township has a ¼-inch stream which has decreased in volume. In section 28, a flowing well sunk in 1892, is now operated by a pump handle.

In Kawkawlin township a number of well records collected by Mr. W. T. Shaw, show a constant diminution in the volume of both flowing and non-flowing wells. In section 3, a well sunk in 1871 stopped flowing in 1884, and is now four feet from the top. Later in 1875, another well in section 34 with the water two feet from the top at that time, was considerably lower in 1900. A well sunk in section 8, in 1878, flowed for three years, and is now eight feet from the top. A well dug in 1884 in section 19 was somewhat lower in 1900. A well in section 34 was two feet below the surface in 1892, and six feet in 1900. A flowing well put down in 1894 in section 5, flowed one year. In 1900 it was nine feet below the surface. Likewise in the same year, another well in section 31, which then flowed two and a half feet above the top, now flows a small stream one foot above the surface. In 1895 a well in section 27 flowing one foot above the top, was in 1900, six feet below the surface. In section 32, still another well flowing a half inch stream one and a half feet above the top in 1896, ceased to flow in 1900. Another non-flowing well put down in the same section in the same year, was at that time six feet below the surface, is now much lower. In 1897 a flowing well in section 23, which then rose one and a half feet above the ground level, had ceased to flow in 1900. Another well put down in the same year in section 34, flowed one foot above the surface at that time; in 1900 the water level was 3.5 feet below the ground.

It is said that the first flowing well in Williams township was put down in section 4, in 1887. The flow was constant in 1900. The area of flowing wells in this township is rather limited.

Altogether the area of flowing wells, and the amount of flow may be said to be constantly diminishing. It would very likely be advisable to keep the water partially shut off when not in use.

Character of the Water.

The following notes are taken from the report of F. D. Owen on "Some Field and Laboratory Tests of Bay County Waters."[1]

"With reference to the applicability for boiler use, we note that the presence of calcium and magnesium carbonate and sulphate, oxides of iron and alumina and silica, constitute the encrusting solids, and that the presence of sodium chloride or brine in a water makes it very injurious to metal fittings as bolts, rivets, etc." Waters of this character were found in the drift at a depth varying from 55 to 113 feet, and in shaft No. 2 of the Bay County Coal Mining Co. at 150 feet. The deep Cherry well, however, already referred to, has none of these objectionable properties.

"According to the results, sodium sulphate and calcium sulphate or gypsum, may be said to occur most frequently in deep rock wells. Carbonate of lime appears to be most abundant in the deeper and rock wells. In the laboratory the waters often contained a considerable deposit of various salts and iron which had been in the form of carbonates, showing that a certain

[1]Report of the State Board of Geological Survey of Michigan for the year 1902, p. 10.

amount of carbonic anhydride had been present, but had been lost in transit to the laboratory."

"The hardness of the water shows it to be the greatest in drift, and least in deep rock wells, although in some cases the deep wells possess considerable hardness." Reference has already been made to the brackishness of the Bay county waters.

Herewith are presented the details of Floyd D. Owen's work in Bay county during the summer of 1902. Townships are arranged alphabetically, and under that numerically by sections.[1]

Beaver Township.

Section 2, Wm. Soper's mill. Driven well 66 feet deep in drift. Cl medium, Ca O, SO_4 O, CO_2 2, hardness 20 c.c.

Kawkawlin river, section 3, E. line. Surface water yellowish color, not colorless, but clear, river low and slow moving. Cl O, SO_4 O, Ca O, CO_2 O.

John Novak, section 15, east line. Driven flowing well 75 feet deep in drift. Ca trace, SO_4 O, Cl medium, CO_2 4, hardness 11 c.c.

Former Cherry well, section 16, E. line. Driven well, 173 feet deep in drift, fresh, soft, used for washing, iron in water. Ca O, SO_4 O, Cl medium, CO_2 3, hardness 6 c.c.

John Betzold, section 22, E. line. Well 16 feet deep in drift, bricked. Cl strong taste, SO_4 trace, Ca trace, CO_2 5, hardness 6.5, iron O.

John Endline, section 22, E. line. Driven flowing well 100 feet deep, 14 feet into rock, 8-9 years old, flow from drift (?). Ca low trace, Cl medium, SO_4 trace, CO_2 3, hardness 13 c.c., iron low.

Wm. Regenstein, section 26, W. line; 108 feet deep in drift, very salty, iron, big flow.

Celo Cessube, section 27, E. and S. line; 16 feet deep, dug, never dry. Also has driven flowing well, but prefers to use dug well. Flowing well 82 feet deep with some iron and salty. In dug well: Ca trace, SO_4 O, Cl medium, CO_2 4, hardness 7 c.c.

A. Emmet, section 35, W. line. Driven well 93 feet in drift, flowing 2-inch stream. Cl strong brine, Ca trace, SO_4 trace, CO_2 .3, hardness 10 c.c., iron quite strong.

Fraser Township.

M. Tebo, section 9, W. line. Driven flowing well 55 feet deep in drift, 11 years old. Cl trace, SO_4 trace, Ca trace, CO_2 4, hardness 7 c.c. iron low.

Wm. Hodder, section 22. Driven flowing well 45 feet deep, seven years old. Cl medium, Ca O, SO_4 O, CO_2 .3, hardness 15 c.c., iron trace plus.

Joseph Kerr, section 22. Flowing well 41 feet deep in drift, 12 years old. Cl medium, Ca trace, SO_4 O, CO_2 trace, hardness .9, iron trace.

Lengsville, section 26, center. Driven flowing well 45 feet deep in drift, Seven years old. Cl strong, salty, Ca trace, SO_4 trace, CO_2 .3, hardness 20 c.c., iron low.

H. Leavens, section 28. Driven well 85 feet deep, water within 3-4 feet

[1]Mr. Owen used a soap solution of such strength that one c. c. would be precipitated by 7-10 of a milligram of Ca CO_3.

To convert the hardness, figures herewith given into "degrees of hardness on Clark's scale," multiply the number of c. c. used by .49.

One degree on Clark's scale means one grain of Ca CO_3 in one gallon (70,000 grains) of the water. If the water runs less than 6 degrees it is usually considered fairly soft.

of the top, four years old. Cl low, SO_4 trace, Ca trace, CO_2 1 c.c., hardness 5 c.c., iron low.

Chas. Flood, section 30, S. W. corner; 190 feet deep, dug 1901. Cl low, SO_4 O, Ca O, CO_2 trace, hardness 19 c.c.

Wm. Clancey, section 33. Driven well 97 feet deep into rock, dug 1898. Cl medium, Ca O, SO_4 O, CO_2 trace, hardness 20.

J. S. Bouchard, section 34, S. line. Dug well 11 feet deep, dug in 1901. Cl, SO_4, Ca O, CO_2 .9.

Garfield Township.

Rogers (?), section 34, E. line. Driven well 112 feet deep in drift. Cl O, SO_4 medium to low, Ca low, CO_2 1 c.c., hardness 6 c.c., iron trace.

Kawkawlin Township.

Joseph Granger, section 2, S. line. Driven flowing well, 1897. Cl medium, Ca and SO_4 trace, CO_2 .5, hardness 8 c.c., iron medium.

Wm. E. Eker, section 2, N. E. corner; 70 feet deep into rock, flows. Cl medium, Ca trace, SO_4 trace +, CO_2 6, hardness 9 c.c.

D. B. Senay, section 3. Dug well 11 feet deep, dug 1890, rather soft, used for washing.

P. Lemieux, section 4, S. E. corner; 77 feet into rock. Cl medium, SO_4 trace, Ca trace, CO_2 trace, hardness 6 c.c.

Chas. Bevan. Driven well 78 feet deep into rock, formerly flowed. Cl medium, SO_4 trace, Ca trace, CO_2 .1, hardness 16 c.c.

Monitor Township.

Section 17, Wolverine Mine No. 2, water from 140 feet, Cl very strong, SO_4 O, Ca trace +.

Wm. Geiser, section 19, depth 14 feet in clay, never dry. SO_4 slight trace, Ca low, Cl medium, CO_2 2.5 c.c., hardness 4.5 c.c.

Pinconning Township.

Chas. Tremlien, section 11, N. line. Dug well 14 feet deep in drift, dug 1895.

Ernest Ruetz, section 21, S. W. part. Flowing well 52 feet deep, water from drift. Cl, SO_4, Ca trace, CO_2 .3, hardness 5.5.

L. Lapean, section 22. Driven flowing well 28 feet deep in drift, dug 1896. Cl low, SO_4 trace, Ca trace,— low, CO_2 2, hardness 5 c.c.

In Pinconning village, section 23, E. of hotel, depth 50 feet. Cl Ca, trace, SO_4 low, CO_2 .8, hardness 12 c.c.

School house, section 25. Driven flowing well. Cl strong, Ca low, SO_4 trace, CO_2 1 c.c., hardness 4.5 c.c., iron lots.

H. Schiminski, section 33, N. line. Driven flowing well, 75 feet deep into rock, used in boiler of creamery, and since December 5, 1900, has formed no more scale than an egg shell (written in summer of 1902). Cl trace, SO_4 low +, Ca and CO_2 trace, hardness 4 c.c.

Geo. Esseltine, section 33, W. line. Flowing well 56 feet deep, dug 1896, into rock. Cl trace, SO_4 medium, Ca trace, CO_2 1.1 c.c., hardness 6 c.c., iron low.

West Bay City.

State Street, just north of cemetery. Spring 11 feet deep (?), wood curbing, lots of water (probably at foot of Algonquin beach). Cl, Ca, SO_4 O, CO_2 1.2, hardness 14 c.c.

Williams Township.

S. Rowden, section 11, north line. Dug well 113 feet deep and 26 feet into rock, dug in 1892. Cl very strong, SO_4 O, Ca medium, CO_2 1.3, hardness 6 c.c., iron O.

G. A. Meyers, section 12, W. line. Flowing well 67 feet deep into drift, dug 1900. Cl strong, Ca O, SO_4, CO_2 trace, hardness 6 c.c., iron O.

B Phillips, section 14, W. line. Driven well 99 feet deep in drift, dug 1895, water seven feet from top. Ca low, SO_4 O, Cl medium +, iron none, CO_2 1.6, hardness 6.5 c.c.

Hotchkiss, section 15. Dug 98 feet in drift in 1898 or 1890, never dry. Ca trace, SO_4 trace, low, Cl strong, iron low +, CO_2 .3 c.c., hardness 6 c.c., water 7-8 feet from top in summer 1902.

Chas. White, section 22, E. line. Dug well 16 feet deep, 1889. Ca trace, SO_4 O, Cl medium, CO_2 1.3, hardness 12.5 c.c.

Kolb Bros, section 23, E. line. Drive well 217 feet deep in drift, drove in 1900. Ca, SO_4 O, Cl, trace, CO_2 .5 c.c., hardness 11 c.c., iron O.

Richard Turmelle, section 23, W. quarter post. Dug well nine feet deep in clay, dug 1901. Cl low +, SO_4 O, Ca very low, CO_2 1.1 c.c., hardness 5 c.c.

The following analyses are also taken from Mr. Owens' report:

	1.		2.		3.		4.		5.	
	Found 200 c.c.	Parts per 1000.	Found 200 c.c.	Parts per 1000.	Found 200 c.c.	Parts per 1000.	Found 200 c.c.	Parts per 1000.	Found 200 c.c.	Parts per 1000.
Total solids	2.380	11.90	.2534	1.2670	.1805	.9025	2.866	5.732	.375	.750
Total organic	.1965	.9825	.1014	.5070	.010	.050	.570	1.140	.135	.310
Total inorganic	2.1835	11.0175	.1520	.7600	.1705	.5825	2.296	4.592	.220	.440
Ca O	.0673	.....	.0454	.....	.01154	.....	.01826	.....	.00226	.....
$CaCO_3$	.....	.4290	.....	.37254	.....	.01383	.....	.....	.....	.....
$CaSO_4$	.....	.20625	.....	.04454	.....	.10706	.....	.08868	.....	.01096
Al_2O_3, Fe_2O_3	.00806	.4030	.06876	.....	.00176	.00880	.01286	.02572	.00086	.00172
MgO	.01394	.....	.02263	.....	.00386	.....	.0005	Mg SO_4 .0030	.00053	Mg SO_4 .00318
$MgCO_3$	.....	.14635	.....	.23767	.....	.04053	.....	.....	.....	.....
SiO_2	.01106	.05530	.00706	.0353	.00326	.0083	.01386	.02772	.00906	.01812
Na Cl	2.00304	10.01152	.05148	.2574	.09009	.45045	2.19375	4.3875	.17555	.35110
SO_3	.0220	.....	.00524	.....	.01142	.....	.0508	Na_2SO_4 .08418	.01399	Na_2SO_4 .03446

	1		2		3		4		5	
	Parts per 1000.	Grains per U.S. gal.	Parts per 1000.	Grains per U.S. gal.	Parts per 1000.	Grains per U.S. gal.	Parts per 1000.	Grains per U.S. gal.	Parts per 1000.	Grains per U.S. gal.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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Sample No. 1. Sam Bowden. N. Williams. 113 feet deep. pumped. rock well.

No. 2. Chas. White. 16 feet. clay. dug.

No. 3. Ecciine. 100 feet. clay. sand. gravel. rock. flowing.

No. 4. Meyer. 67 feet. gravel. flowing.

No. 5. Cherry. 150 feet. drift. flowing strong.

No. 6. Kawkawlin river. surface water.

No. 7. Bay Mine. 150 feet below. from coal. not used.

No. 8. Wolverine mine. bedrock water.

No. 9, Elmer or Lutz. clay. 93.5 feet. flow.

No. 10. M. Tebo. 55 feet. clay. clay and sand.

Water Temperatures.

The following observations were taken with an H. J. Green standard thermometer number 7529. In the shaft of the What Cheer Mine in section 30. T. 13 N., R. 6 E., the temperature of the water at a depth of 139 feet was 54.5°; at depths of 155 and 195 feet the temperature was 54°. In a shaft located one and a half miles east of Auburn. water pumped in large volume from a depth of 90 feet. was constant at 50° Fahr.

Mr. Lane obtained the following observations: At Pinconning a flowing well near the S. W. corner of section 27. depth 45 feet. had a temperature of 51.5°. June 14, 1900. Also at or near Riches bakery. Pinconning. a well 53 feet deep was 48.5°, August 6. 1901.

From August 12-26. 1904, the average temperature of Saginaw bay. near the shore of Saginaw bay, was 72.11°; during the night of August 22-23 and 25-26, 1904, 66.54°.

Water Supply for Bay and West Bay Cities.

Bay and West Bay Cities obtain their supply of water from Saginaw bay, like almost all the cities adjacent to the Great Lakes. This source of supply. even when obtained in cribs at a fair distance from the shore. is open to the objection of being polluted by drainage during periods of low water. or when the breeze is off shore, causing the river to flow north toward the intake pipes. It would also doubtless be advantageous to locate the intakes where the bottom is clay or sand. and free from organic matter.

A possible remedy for this may be found in the fine water obtained from the Marshall sandstone in Huron county. At Bad Axe the Coryell Drilling Co. is said to have drilled a well which produced 4,000,000 gallons every 24 hours. I do not imagine, however, that this will last unless carefully conserved.

Another project which has been discussed by Mr. E. L. Dunbar, Supt. of the Bay City Water Works Dept., involves the plan of obtaining water from the Tittabawassee river. Providing the quality was suitable, it would also be necessary to determine from the U. S. Government gage station at Freeland and Highwood, whether the amount was sufficient to supply future development. The elevation of the Michigan Central bridge over the Tittabawassee river at Highwood is 693 feet A. T. The top of the divide on the Midland road, and east of Midland City is very nearly 669.5 feet A. T., so that there is no insuperable engineering difficulty to overcome in order to bring the water to Bay City by gravity. However, probably the best solution to the question is to obtain water from the present source, removing contamination by filtration methods similar to those employed at Albany, N. Y. and Hamburg, Germany. Whether it would be advisable for the Bay and Saginaw cities to unite in a project of this sort, is a problem for the sanitary engineer to determine.

Since the above was written Mr. J. H. Tryon of West Bay City has given the Survey a sample of mine water containing 685 thousandths of one per cent. of sulphuric acid. This was from the abandoned entries of Wolverine No. 1 Mine near Wenona beach. The presence of sulphuric acid in the water is due to the oxidation of iron pyrites.

10. *Well Records.*

BANGOR TOWNSHIP.

Section 4.

Near the east quarter post. Goff Paul, driller. Salt water at 100 feet.

Cole. In the S. E. ¼ of the S. E. ¼. Dug well 22 feet deep, sand and muck for 6 feet, the rest being clay, never dry, 10 feet from top, in summer, hard.

Carter, in the N. E. ¼ of the S. W. ¼. Dug well 16 feet deep in clay, never dry, water 4 feet from top, hard.

Section 6.

In the N. E. ¼ of the N. E. ¼. Dug well 22 feet deep; 6 feet sand on the top, then clay; never dry, low in summer, hard.

Section 7.

Oeder. Coal hole 200 feet deep, 175 feet drift. Dug well 31 feet deep in clay, hard; never dry; water 4 feet from top in spring.

Section 8.

In the S. E. ¼ of the N. E. ¼. Dug well 22 feet deep, water 3 feet from top; hard, never dry.

Kayner. Dug well 14 feet deep in clay; hard, fresh; 4 feet from top, never dry.

Section 17.

Sage Land Company. Well at house 115 feet deep; rock at 100 feet with water which is hard and salty, 24 feet from top.

Another well 60 rods east,118 feet deep, rock 100 feet?, trifle salty, water 12 feet from top; wind from east, plenty of water; from S. W., W., N. W. not much.

Another well 160 rods east 200? feet deep, flow of water at 92 feet, fresh; rock at 90 feet.

Another well 20 rods southeast 180 feet deep, rock at 120 feet, no water.

Section 18.

Wilder, in the N. W. ¼ of the N. E. ¼. Dug well 16 feet deep, hard; surface water 4 feet from top in spring, never dry.

Section 19.

In the S. E. ¼ of the S. E. ¼. Dug well 20 feet deep in clay, water 6 feet from top, hard.

Emery. In the N. E. ¼ of the N. E. ¼. Drilled well 220 feet deep, 130 feet to rock, no sand below the clay, water 70-90 feet; 8 feet from top, hard, fresh.

Center. Rock at 117 feet, buried trees at 80 feet in clay, 4 feet thick, boulders in clay below.

G. A. Meed. Ninety-four feet to rock, clay to rock; water on top of sandrock.

Section 31.

A. S. Cody. In the S. E. ¼ of the N. E. ¼. Rock at 106 feet; 5 feet of marble (hard white sandstone) at 280 feet.

Section 32.

Bay shore and east 80-rod line. Seven feet white sand, then 19 feet clay, boulder of gypsum here.

In the N. W. ¼. Dug well 12 feet deep, 6 to 10 feet of sand, rest clay, never dry, hard, 3 feet from top.

Bay View foot of Henry St., 80 to 85 feet to rock, blue shale 30 feet, then sandstone to 130 for 25 feet + then 4 feet coal, then 3 feet fire clay. At 250 feet and 4 feet coal. West about the same.

Taylor, in the S. E. ¼ of the N. W. ¼. Rock at 45? feet.

East quarter post. Rock at 130 feet.

BEAVER TOWNSHIP.

Section 2.

Soper. Flowing well 112 feet deep, fresh; clay for 63 feet then hardpan for 20 feet, then gravel with water, medium hard.

Another well 63 feet deep in drift; ¼ medium flow, steady, fresh, medium hard.

Section 7.

Near the east quarter post, school house. Drilled well 150 feet deep. Water at 78 feet, fresh; 2 feet from top. Four feet coal, 138 feet from top.

Section 10.

Swiecicki. Flowing well, 84 feet deep in clay, small flow, fresh.

Section 15.

Schnett. Flowing well, 120 feet deep, good flow, fresh; all in drift, medium hard. Well drilled in 1897.

J. Novak. Flowing well 75 feet deep in drift, fresh, very fair flow.

Section 16.

Cherry. Flowing well 14 feet above ground, soft and fresh. Well down 10-12 years Well 173 feet deep, rock at 80 feet?, one flow at 103 feet, big flow at 173 feet.

Section 18.

Schlink, Dug well 9 feet deep, 5 feet of sand on top, rest clay; well dry in summer water soft at first, harder now.

Section 20.

Kraft. Flowing well 197 feet deep in drift, fresh, soft; flows 3 feet above surface, well put down in 1895.

Lindsay. Drilled well, 93 feet deep, clay for 80 feet, then rock—blue slate, water 4, feet from top, fairly soft, fresh.

Section 21.

Church—Lutheran. Drilled well, 126 feet deep, top 60 feet clay.
In another well 80 feet of quicksand below clay; water soft, fresh, 3 feet from top.
In the N. W. corner Kimel's store. Flowing well, 148 feet deep; full inch flow; 5 feet above top, 136 ? feet to rock, water soft, fresh.
Kimel. Flowing well 140 feet deep, water soft, fresh, fair flow; 4 feet above top.

Section 22.

Betzold. Flowing well 111 feet deep in drift, fresh, soft.
Bacon. Flowing well 187 feet deep, soft, fresh; one pail in six minutes.

Section 23.

Ederrer. Flowing well 73 feet deep; very fair flow in drift, fresh, soft.

Section 24.

Loehne. Eighty-seven feet deep in drift; soft, fair flow, not salty.
Another well, 136 feet in clay; soft, fresh, no flow.

Section 26.

Peltier. Flowing well.
In the N. W. ¼ of the N. W. ¼. Medium flowing well 85 feet deep, very little salty.

Section 27.

Walters. Small flowing well 85 feet deep, hard, very little salty.
Ittner Small flowing well 83 feet deep, all in clay, fresh, soft.

Section 29.

Horschig. Well 85 feet deep in clay, gravel and sand; water 6 feet from top in wet weather.

Section 31.

Herman. Dug well 14 feet deep; 7 feet sand on the top, rest clay. Water in gravel bed, never dry, 4 feet water now.

Section 32.

Peoples. Drilled well 74 feet deep; well used to flow, water 2 feet from top, all in drift; sand at the bottom, fresh, hard.
Livingston. Drilled well, 130 feet deep in drift, mostly blue clay, water in sand and gravel bed; water 15 feet from top, medium, hard, fresh.

Section 33.

Tonke. Flowing well 80 feet deep in drift, fresh, soft.

Section 34.

Wirsing. Drilled well 114 feet deep, rock at 70 ?. Water just to top, little salty, hard, probably from gravel over rock.
J. Sullivan. Drilled well 82 feet deep in drift; water 4 feet above, gravel, salty, hard.
Mueller. Flowing well 80 feet deep, fresh, all in drift.
Morrison. Flowing well 145 feet, rock at about 85 feet; flowing in gravel above rock, salty, hard, small flow.

Section 35.

Lutz. Strong flowing well, fresh, 93 feet deep in drift.

FRANKENLUST TOWNSHIP.

Section 1.

Engelhardt. Dug well 18 feet deep in clay, never dry; water 4 feet from top, soft, fresh.

Michigan House. Drilled well 106 feet deep; water at first 4 feet from top. Drained by Pittsburgh shaft near Amelith; trifle salty, rock at 90 feet.

Section 4.

In the S. W. part. J. M. Weiss. Rock at 147 feet, clay for 120 feet, then sand and gravel.

Section 5.

Lutz. In the S. E. ¼ of the S. E. ¼. Drilled well 104 feet deep. Clay to 104, sand below with water which is 28 feet from top, fresh and soft.
Behmlander. Dug well 20 feet deep in clay; water in spring 2 feet from top; sometimes dry in summer, hard.

Section 6.

Schlicker. Dug well 56 feet in drift, never dry.
Kasemeier. Dug well 20 feet deep; sometimes dry in summer.

Section 7.

Trautner. Dug well 18 feet deep in drift, never dry; water 10 feet from top, fresh and hard; water from west.

Section 8.

In the N. E. ¼ of the S. E. ¼. Dug well 18 feet deep in clay, never dry; water to top in spring.

Section 11.

Roth. Dug well 11 feet deep in clay. Sometimes dry in summer; water hard.

Section 12.

J. Neumeyer. Dug well 11 feet deep in clay. Dry sometimes in summer.

Section 14.

J. C. Neumeyer. Rock at 82 feet, 10 feet in rock; water is fresh, 5 feet from top; 10 feet sand on top, the rest being clay.
G. Neumeyer. Drilled well 130 feet deep, rock at 112-115 feet; 3-4 foot sand on the top, then drift; water at 85 feet up to 3 feet from top, fresh and hard; salty water at 130 feet or less.

Section 15.

J. A. Lutz. Drilled well 82 feet deep, sand 82 to 114 feet, rock at 114 feet; water here at 18–20 feet.

Section 16.

Redinger. Dug well 16 feet deep. Sometimes dry in summer.
Weggel. Dug well 20 feet deep in drift. Seldom dry, water 3 feet from top.

Section 17.

Wirth. Dug well 17 feet deep in drift. Seldom dry, water 3 feet from top, fresh and hard.
Haag. Dug well 18 feet deep in clay; never dry, water almost to the top, hard
In the S. E. part of the N. W. ¼ of the S. E. ¼. Rock at 137 feet, white sandstone at 225 feet.

Section 18.

G. Maurer. Dug well 22 feet deep; 4 feet black loam on the top, then reddish soil, the rest clay; water 10 feet from top in dry weather, never dry.
Ludgin. Dug well 18 feet deep in clay; plenty of water, hard.

FRASER TOWNSHIP.

Section 2.

In the N. E. ¼ of the S. E. ¼. O. Ouilettee. Flows steadily; put down in 1898; 28 feet to rock.

Section 4.

In the N. W. ¼ of the S. E. ¼. R. Williams. Flows 3 feet above surface a ½-inch stream; drilled in 1897; slightly mineral; 30 feet to sandstone.
In the S. ¼ post. Mary Coggins. Flows 2 feet above surface; 72 feet to rock.
In the S. E. ¼ of the N. W. ¼. J. P. Johnson. Forty-five feet to rock.
In the N. W. ¼ of the S. W. ¼. Dan Whyte. Flows ½-inch stream; slightly mineral; 28 feet deep.

Section 6.

In the N. E. ¼ of the S. E. ¼. F. Johnson. Flowing 2.5 feet above surface; ½-inch stream; put down in 1898; flow decreasing.
In the W. ½ of the N. W. ¼. Joseph LeFeure. Water to surface but not flowing; 70 feet to rock.

Section 7.

In the S. E. ¼ of the N. W. ¼. F. R. Wright. No flow; 60 feet to rock.

Section 8.

In the N. W. ¼ of the S. W. ¼. M. Coggins. Fifty-one feet to sandstone.

Section 9.

Near the W. ¼ post at Tebo's store and P. O. Flows ½-inch stream; slightly mineral; 50 feet deep, but not to rock.
Near the E. ¼ post. W. H. Curts. Water near the surface; 36 feet deep; not to rock.

Section 11.

In the N. ½ of the S. E. ¼. F. Davis. Flowing a one-inch stream; 2 feet high; slightly brackish; 60 feet to rock.
In the S. W. ¼. Michie P. O. Thirty-nine feet to rock.

Section 12.

In the N. E. ¼ of the S. W. ¼. E. Pommerville. Flowing a ½-inch stream; drilled 55 feet to rock.
In the N. W. ¼ of the N. W. ¼. J. W. Smith. Flows an inch stream; 2 feet above the surface; not salty; 40 feet deep.

Section 13.

In the N. W. ¼ of the N. W. ¼. Frank Oreonette. Flows a one-inch stream with force 18 inches high; strongest well seen yet; slightly mineral; 42 feet to rock.
In the S. E. ¼ of the S. W. ¼. Strong flow; 2 feet above ground; one-inch stream; not mineral; 48 feet deep.

Section 16.

In the N. W. ¼ of the S. W. ¼. Mill well. Water 6 feet below surface; 90 feet to rock.

Section 17.

In the W. ½ of the S. E. ¼. M. Jean. Dug 18 feet deep.

Section 18.

M. O. Bill. Water not brackish; not flowing; 55 feet to rock.
In the N. E. ¼ of the N. W. ¼. Flow has ceased; traces of iron; 128 feet to water; goes into rock.

Section 19.

In the E. ½ of the S. E. ¼. John Bastow. No water; 90 feet to rock.
In the S. W. ¼ of the S. W. ¼. Thos. Salmen. Not to rock; water 2 feet below surface, which is found at 85.

Section 20.

In the N. E. ¼ of the N. E. ¼. Wm. Hodder. Water mineral; 70 feet deep.

Section 22.

In the N. E. ¼ of the S. E. ¼. Jos. Kerr. Flowing a one-inch stream 3 feet high.
In the N. E. ¼ of the N. E. ¼. Wm. Hodder. Flows a 2-inch stream 2 feet high; slightly mineral; 45 feet deep.

Section 26.

In the S. W. ¼ of the S. E. ¼. Flowing one foot high; quite brackish; 48 feet to rock; said to have run a 2-inch stream at first; ¾-inch stream in 1900.
In the S. W. ¼ of the N. W. ¼. Water at 60 feet; drilled on for more to a depth of 109 feet; slightly mineral; ½-inch stream.
In the S. W. ¼ of the N. W. ¼. Flows a ½-inch stream; 43 feet to rock.

Section 28.

In the E. ½ of the N. W. ¼. M. W. Glaspie. Water not mineral; 55 feet deep; drilled in 1892; flowed at first; pump now used.

Section 29.

In the N. W. ¼ of the N. E. ¼. John Bartholomew. Dug 10 feet deep.

Section 30.

In the W. ½ of the S. W. ¼. No water at all; 80 feet to rock; 4 feet into rock.

Section 32.

In the N. ½ of the S. E. ¼ of the N. E. ¼. J. Perrond. Sixty-two feet to rock; 30 feet in rock; water not good; black; says there is coal there.

Section 33.

In the E. ½ of the S. W. ¼. Wm. Clancy. Water to surface; lowers some in summer; 106 feet deep to hardpan.
In the W. ½ of the W. ½ of the S. W. ¼. J. Hertier. Flows ½-inch stream; slightly mineral; 75 feet deep.

Section 34.

In the N. E. ¼ of the N. E. ¼. Adolph Rivard. Total depth is 97 feet; 10 feet in rock; ½-inch stream. Drilled by Mr. King of Linnwood in 1896.

Section 35.

In the N. W. ¼ of the S. W. ¼. Not much water; 80 feet to rock. Dug 12 feet and got plenty of water.
In the S. W. ¼ of the S. E. ¼. Fowlers. Water quite brackish; within 2 feet of surface; 60 feet to rock.

Section 36.

In the S. W. ¼ of the S. W. ¼. Flows ½-inch stream 18 inches above surface; 60 feet to rock; brackish.
North of Linwood and on Bay shore bed rock at 50 feet steady?

GARFIELD TOWNSHIP.

Section 24.

In the S. E. ¼ of the S. E. ¼. E. W. Brown. One hundred thirty feet to rock; 5 feet in rock to water; water within 2 feet of surface; bed rock, first 50 feet of dry hole; 115 feet of sandstone; traces of coal.

Section 25.

In the S. W. ¼ of the S. E. ¼. Chas. Carey. Water 3 feet from surface; not mineral; 80 feet to rock.

Section 26.

In the S. W. ¼ of the S. W. ¼. Sawmill. Flowing a one-inch stream; not mineral; 112 feet to a bed of gravel; not to rock; (probably just to rock).

Section 28.

In the S. W. ¼ of the S. W. ¼. M. Schmidt. Dug well 12 feet deep.

Section 34.

In the N. E. ¼ of the N. E. ¼. Store. Practically the same as the well in the S. W. corner of Section 26, except that the water stands 5 feet below the surface.

Section 35.

In the S. W. ¼ of the S. W. ¼. A. T. Holcomb. Through 75 feet of clay and 25 feet of hardpan; 8 feet of sand; water within 5 feet of surface.

Gibson Well Records.

Section 1.

In the E. ½ of the E. ½ of the S. E. ¼. Winkel. Drilled 50 feet m the earth to bed of sand; flow; stream dried up.

Section 10.

In the N. E. ¼ of the S. W. ¼. Well 40 feet deep but not to water, thinks not to rock.

Section 12.

In the N. W. ¼ of the N. E. ¼. Walters. Dug 12 feet; 2 feet of water; nearly dry.

Section 20.

Wm. Hinman, Bently. Well 160 feet deep, clay for 115 feet to sandrock. Water from the rock within 32 feet of surface.

Section 29.

In the N. W. ¼ of the N. W. ¼. E. Harvey. Dug 20 feet and got water, then drilled 80 feet in clay to rock without getting more water. Pettit of Standish, driller.

HAMPTON TOWNSHIP.

Section 3.

Four-tenths of a mile east of the N. W. corner. Dug well 14 feet deep in clay, water 3 feet from top. Never dry, hard.

Section 8.

Near the center, ½ mile S. E. of Oak Grove hotel. Rock at 85 feet. At top sandrock, then shales, then 2 feet of coal at 125 feet, then gray shale, blue shale, and fire clay. Bottom soft white sandrock to 400 feet.

Section 13.

McDonald. Dug well 30 feet deep, never less than 12 feet of water. Mostly till, hard, fresh.

Section 15.

Woodbury. Drilled well 150 feet deep. Seventy-nine feet to rock, clay to rock, 4 feet 2 inches black shale—coal, then 2 feet of fire clay at 120-130. Rock below very hard, trifle salty, water at 127 feet below. Water varies from the top to 20 feet very suddenly. High at the time of the Galveston cyclone.

One-tenth of a mile S. of the E. ¼ post. Dug well 15 feet deep, 7 feet sand on the top; never dry, hard.

Section 17.

One-tenth of a mile N. of the S. E. corner. Drilled well 80 feet deep, least salty; water 5 feet from top; clay and gravel on top with shells.

Section 18.

Vink. Dug well 18 feet deep in clay. Dry in summer; sometimes hard.

Fisk. Dug well 13 feet deep in clay, hard, generally dry.

Section 19.

P. Wagner. Drilled well, bed rock at 80 feet, depth 108 feet, water fresh, 10 feet from top. Never dry.

Section 20.

One-half mile S. of the N. E. corner. Dug well 22 feet deep, hard water, never dry.

J. VanWort. Drilled well 120 feet deep, 80 feet to rock, fresh and dirty.

Section 21.

Remington. Dug well 80 feet in clay; water 60 feet from top now, fresh. Ten feet yellow clay—rest blue.

Section 25.

Engelhardt. Eighteen feet deep, water 2 feet from top, hard, never dry.

Section 26.

Near the S. ¼ post. Dug well 12 feet deep in clay, never dry.

Section 29.

Meyer. Drilled well at 85 feet deep, all in drift, plenty of fresh water at 85 feet. Water 16 feet from top.

On the S. line, .6 miles E. of the S. W. corner. Dug well 13 feet deep in clay, dry in summer.

Section 30.

VanSonieren. Drilled well 100 feet deep, 85 feet to rock. Water at 85 feet, 20 feet from top, fresh, never dry.

VanSonieren. Dug well 21 feet deep. Never dry in 3 years. Varies in level; full in spring.

Section 34.

Jos. Kraus. Dug well 20 feet in clay, never dry; water 4 feet from top.

Section 35.

In the S. W. ¼ of the N. E. ¼. Maxwell. Ninety-three feet to rock. At 176 feet salty water. Black shale at 125 feet.

Section 36.

In the N. E. ¼ of the N. E. ¼. About 85 feet to rock, water salty, not near the top.

KAWKAWLIN TOWNSHIP.

Section 2.

Allen. In the N. E. ¼ of the S. E. ¼. Flowing 18 inches high. One-fourth inch stream.

Bond. In the S. W. ¼ of the S. W. ¼. Seventy-six feet to rock, flowing; 67 feet through hard dry clay; 8 feet through putty clay.

Lutz. In the S. E. ¼ of the S. E. ¼. Seventy-four feet to rock.

Section 3.

In the N. W. ¼ of the N. E. ¼. Well east side of State road. Flowed at 70 feet on rock, then ceased to flow, and was drilled 50 feet into rock, water now at surface.

Senay. In the N. W. ¼ of the S. E. ¼. Seventy-five feet to layer of sand through clay, flowed at one time, now 2.5 feet from top.

Seeley & Parsons. In the N. W. ¼ of the N. E. ¼ west of the State road. Flowed when put down in 1871, 70 feet through clay and one foot to gravel, probably to rock surface. Cased with wood, bored with 6-inch auger. Water ceased to flow 6 years ago. Now 4 feet from top.

Section 4.

In the N. E. ¼ of the N. W. ¼. Chas. Beran. Dug well, 10 feet to water.

Lemieux, H. In the S. E. ¼ of the S. E. ¼. Drilled well 72 feet to rock through 66 feet of clay and 6 feet of sand, water 6 feet from top.

Section 5.

In the E. ½ of the N. W. ¼. Mary Wasser. Drilled 83 feet to rock by Lemieux of Kawkawlin township, water within 2 feet of surface, constant, said to get roilly before a storm.

In the N. ½ of the N. E. ¼. Katie Regan. Eighty-five feet to rock and 5 feet in the rock. Water quite soft and does not taste mineral. Stream small ¼-inch stream.

Rivard. In the S. E. ¼ of the N. E. ¼. Seventy feet to rock, 31 feet in rock to water, through clay, water 9 inches from top, put down 18 months (1900))

Well on same place. Seventy feet to rock, flowed at first one year, put down in 1894.

Section 6.

Lacy. In the S. W. ¼ of the S. E. ¼. Dug well 18 feet deep, surface 2 feet sand and coal, the remaining distance is hard clay.

Section 7.

O'Connor's. Dug well 22 feet deep in clay, water 10 feet from top.

McGillis. In the S. E. ¼ of the N. E. ¼. Drilled well, rock at 80 feet, no water.

Section 8.

Jones. In the S. W. ¼ of the N. W. ¼. Drilled well, 85 feet to rock, water from gravel bed. Six feet from the top.

Swaffer. In the S. E. ¼ of the N. E. ¼. Well 87 feet to rock, 10 feet in rock, dry clay for 70 feet; flow at 87 feet, flowed about 3 years, put down 12 years, now about 8 feet from the top.

Section 11.

Devault. In the N. W. ¼ of the N. W. ¼. Seventy-six feet to rock; flowing.

Section 14.

Brisette. In the S. E. ¼ of the N. W. ¼. Seventy-six feet to rock, through clay to gravel on rock; pumped by wind mill.

Dubay. Seventy-six feet through clay to gravel on rock.

M. J. Sylvester. In the S. E. ¼ of the S. W. ¼. Eighty feet to flow. Flows a small stream which is stopped by pumping on well across the section line.

Section 15.

Wetters. In the S. W. ¼ of the S. W. ¼. Eighty-seven feet to rock, water 2.5 feet from top.

Section 16.

School house in the S. E. ¼ of the S. E. ¼. Eighty-seven feet to rock.

Section 17.

Oswald. In the N. W. ¼ of the S. W. ¼. Seventy-five feet deep; flowed 8 feet above surface. Located in flats of river below bank, water is soft.

Section 19.

Doty. In the N. E. ¼ of the S. E. ¼. Eighty-nine feet to gravel on rock; put down 6 years ago, has lowered some.

Section 21.

Beamlander. In the S. W. ¼ of the S. W. ¼. Seventy feet to rock, water brackish; 5 feet from top.

A. Hartley. In the E. ½ of the E. ½ of the S. W. ¼ of the N. E ¼. Total depth 175 feet, flows a small stream 6 feet above surface.

Section 23.

E. Peltier. In the N. E. ¼ of the N. W. ¼. Eighty feet to flow, put down in 1897; flowed 1.5 feet above the top, not flowing now, not brackish.

Schmidt. In the N. W. ¼ of the S. W. ¼. Dug well 14 feet deep, 6 feet of water.

Section 27.

Friebe. In the N. W. ¼ of the N. W. ¼. Eighty-four feet to gravel (above rock), water flowed one foot above surface at first, now 6 feet from top, put down in 1895, water brackish.

Dore. In the E. ½ of the S. W. ¼ of the S. E. ¼. Well 122 feet deep, 73 feet to rock, water 4 feet from top, has lowered some.

Section 28.

Purtell. In the N. W. ¼ of the N. E. ¼. Well 160 feet deep, very brackish. Second well 105 feet to sandstone, water not so brackish, not flowing.

Stremple. In the S. W. ¼ of the S. W. ¼. Seventy-six feet to gravel on rock, water one foot from top, never flowed; put down in 1893.

In the S. E. ¼ of the S. W. ¼. Blohm. Well 114 feet deep, 84 feet to rock through clay. In the S. W. part of the township, about 90 feet to rock. All wells through here are much the same; 2 layers of clay—first a hard red clay then 50 feet of softer blue clay.

In the S. E. ¼ of the S. E. ¼. O. J. Bedell. Eighty feet deep, water 6 feet from top.

Section 31.

Hembling. At the Northeast corner. Eighty-two feet in depth to gravel, flowed 2.5 feet above the surface in 1894; flowing a quarter of an inch stream now. One foot above the surface now.

Section 32.

Sprague, H. S. In the S. W. ¼ of the S. W. ¼; 80.5 feet through clay, 8 to 10 inches through shale, one foot into gray sandrock. Put down in 1896, then within 6 inches of the top, now much lower. Sprague, well driller.

L. Smith. In the E. ½ of the N. E. ¼ of the N. W. ¼. Eighty-four feet to gravel on rock. Water flowed one-half an inch stream 1.5 above surface in 1896, not flowing now.

Section 33.

Eighty rods east of the southwest corner. Eighty feet to gravel on top of rock.

Section 34.

Paig. In the N. ½ of the S. W. ¼ of the N. W. ¼. Ninety-two feet deep, put down in 1875; water 2 feet from the top at first, getting lower.

Graham. In the S. ½ of the S. W. ¼ of the N. W. ¼. Eighty-three feet to bed of gravel (above rock?) boulder 12 feet through 12 feet from the top, water 2 feet from the top in 1892, in 1900, 6 feet below.

Shultz. In the S. E. ¼ of the N. E. ¼. Sixty-five feet deep, flowed one foot above surface at first, now 3.5 feet from top, put down in 1897.

MERRITT TOWNSHIP.

Section 2.

Young. In the S. E. ¼ of the S. W. ¼. Rock at 99 feet, well 100 feet deep, clay to rock, salty water clear to top.

Section 3.

Grigg. One hundred twenty-seven feet deep, 90 feet to rock, clay to rock; salty water at 105. At school house ½ mile east fresh water 100 feet and bed rock at 80 to 85 feet.
Schlack. Dug well 18 feet deep, 2 feet sandy loam on top, then 3 to 4 inches of muck, then clay; never dry, hard.

Section 8.

Wyne. Dug well 10 feet deep, 3 feet of sand on the top, rest clay; water one foot below in spring, dry in summer.
Beyer. Dug well 14 feet deep, 2 feet of sand on top, the rest clay; never dry, full in spring, hard.

Section 11.

Leclair. Dug well 15 feet deep in clay, very low in summer, 13 feet below in spring, hard.

Section 12.

Martin. Drilled well 88 feet deep, not to rock, trifle salty; water 8 feet from top. Eighty to 90 feet to rock in this locality.

Section 15.

Ellison. Drilled well 83 feet deep in drift, trifle salty; water 4 feet from the top.

Section 20.

Munger. Dug well 20 feet deep, 1 to 7 feet of sand on top, rest clay. Water 8 feet from the top, hard.

Section 21.

Three-tenths of a mile east of the northwest corner. One foot of muck then till. Running water at 80 which comes 5 feet from the top, fresh.
Histed. Dug well 14 feet deep, 4 feet of sandy loam on the top, then hard clay all the way down; well dry in summer of 1900, hard.

Section 22.

North half. Drilled well 143 feet deep, rock at 80 feet, clay to rock, fire clay at about 100 feet, trifle salty, 2 feet from the top.

Section 24.

Wahrmann. Drilled well 111 feet deep, 80 feet to rock; trifle salty, clay to rock; water 1.5 feet from the top. Water at 180 to 200 feet. Too salty to use.

Section 25.

Hickey. Drilled well 90 feet deep, 89 feet to rock, 9 feet of sand and gravel above rock, clay for 80 feet.
Duby. Drilled well 70 feet deep in drift, salty; water 4 feet from the top. On the top sand beach east and west.

Section 26.

De Paemlaen. Dug well 16 feet deep, all in clay; dry in summer, hard.
Zumback. Drilled well 90 feet deep, rock at 80 feet; trifle salty, no quicksand.

Section 27.

In the N. E. ¼ of the S. E. ¼. Dug well 12 feet deep, 2 feet of muck on the top, rest clay, dry sometimes, surface water.
In the N. ½. Dug well 13 feet deep, 2 feet of muck on top, then one foot of sand, the rest clay, dry in summer.

Section 28.

Thayer. Dug well 14 feet deep in clay, never dry, hard; lots of water.

Section 30.

Blyth. Dug well 20 feet deep in clay. Dry sometimes, fed by surface water, hard.
Lynch. Drilled well 148 feet deep, rock at 85, trifle salty, water at 13 feet from top.

Section 32.

A. Sommerfield. Dug well, 11 feet deep, 2 feet of muck on top, clay below, never dry; lots of water at 6 to 7 feet where there is water bed, hard.
Osborne. Drilled well 158 feet deep, 90 feet casing to rock, salty, water 14 feet from the top.

Section 35.

D. Pommerville. Drilled well 129 feet deep, rock at 87 feet; water salty, never dry.
D. Pommerville. Dug well 16 feet deep, hard, never dry; low in summer.

Section 36.

French. Drilled well 95 feet deep, 4 feet of muck on the top, then clay. About 90 feet to rock, trifle salty; water 6 inches from the top.

MONITOR TOWNSHIP.

Section 1.

T. F. Marston. Dug well 20 feet deep at the foot of Algonquin beach; water is hard.

Section 2.

Fisher. Dug well 20 feet deep in clay, dry all summer, hard.

Section 4.

Beet. Drilled well 74 feet deep in drift-clay, never dry; water 4 feet from the top.
Schwarz. Drilled well 92 feet deep. Dry in summer of 1899.

Section 5.

Sitterding. Dug well 20 feet deep in drift, never dry; water 3 feet from the top, hard

Section 7.

At the north ¼ post. Bed rock at 115 to 120 feet.
In the southeastern part. Rock at 115 feet.

Section 8.

Amsk. Dug well 12 feet deep, one foot sand on the top, the rest being clay; never dry, water 6 feet from the top, medium hard.
Sumner. Dug well 8 feet deep in clay, dry in summer; medium hard.
Periard. Drilled well 110 feet deep, 75 feet of clay, 33 feet of sand, then 2 feet of gravel probably above rock; water in gravel, hard and fresh.

Section 9.

Priem. Dug well 16 feet deep in clay; never clear dry, hard.

Section 10.

M. Arnold. Hard sandrock at 62 feet for 14 to 15 feet, then mixed shale and sandrock for 150 feet, then 3 feet yellowish or blue shale with 4 to 5 inches of coal, then 3

feet of fire clay, then 3 feet of sandstone, then 180 feet in hard white sandrock; 2.5 miles E. Auburn rock at 100 feet and 3 to 4 feet of coal at about 150 feet.

On the north line. Arnold. Drilled well 89 feet deep, 70 feet clay, then 17 feet of sand, rock at 90 feet; never dry; well used to flow, 3 feet below now, little salty.

Schneider. Drilled well 81 feet deep, never dry; water 2 feet from the top, fresh and hard.

Section 14.

Pajot. Dug well 14 feet in clay; never dry; 6 feet from the top, hard.

Section 15.

J. Lejewski. Drilled well 89 feet deep, sand at the bottom; never dry, water 6 feet from the top; trifle salty, magnesium.

At the west ¼ post. Rock at 90 feet.

Section 17.

Sloat. Drilled well 105 feet deep, some clay, then sand; water 3 feet from the top; medium hard.

Krzyzanick, A. Dug well 14 feet deep, sand on the top, then clay; never clear dry, hard.

Section 18.

In the S. E. corner. Rock at 95 feet. At 10 to 12 feet down to 4 feet of sand.

In the southwestern corner. Rock over 173 feet. At 173 feet flow to top for several years. Sand for 70 feet at the bottom.

Section 19.

In the west ¼ post. Rock at 130 feet, 44 feet sand above the rock.

Section 20.

J. Grobe. Drilled well 64 feet deep in drift; never dry, well used to flow 8 feet above the ground, now 3 feet from the top, fresh.

Nesbit. Drilled well 64 feet deep; well used to flow, now 10 feet from surface.

F. Shaw. Rock at 90 feet, 3 feet of coal at 130 feet.

Wm. Shaw. Four feet of coal at 140 feet.

Section 22.

E. Young. Drilled well 82 feet deep, seldom dry, mineral; slightly salty.

Gaffney. Drilled well 157 feet deep, salty.

Another well 123 feet deep with fresh water.

Section 23.

Adams. Drilled well 110 feet deep, rock at 107 feet; 8 feet of sand above rock; plenty of water, fresh; 12 feet from the top.

Section 24.

Kroener. Drilled well 154 feet deep, rock at 85 feet; never dry; fresh water at 60 feet, salty at 154 feet.

J. L. R. Drilled well 88 feet deep, clay and sand, just to rock. Water fresh, used to be level with surface, now 10 feet from the top.

J. L. R. Clay 88 feet, sand to 130 feet, rock 50 feet black shale. Water on the top of rock.

Section 25.

At the Air Shaft of the Central Mine (Knapps). Seventy feet of clay, then 18 inches of hardpan, then into sand, gravel and boulders. One boulder 4.5 feet long, 2.5 feet wide, 22 inches thick, then bed rock.

One-half of a mile west of the Michigan mine. One hundred twenty-two feet to rock.

Section 26.

In the N. W. ¼ of the S. E. ¼. Rock at 80 feet.

Section 27.

Schnell. Dug well 12 feet deep, 5 feet of sand on top, rest clay; well never dry, hard.

Section 28.

Willcox. Drilled well 197 feet, 65 feet of clay on the top, 96 feet to bed rock, 14 inches of coal at 136 to 140 feet; water 45 feet from the top having dropped 9 feet since the well was drilled; water cathartic. About 60-70 rods away plenty of fresh water at 10 feet; fresh.

Section 29.

Feinaur. Drilled well 60 feet deep, some sand below 40 feet; never dry, in spring water is 4 feet from the top, hard and fresh.

Section 30.

J. Zill. Drilled well 117 feet deep, 57 feet of clay, 60 feet of sand, then gravel; never dry; water 12 feet from the top, fresh.

Gavin. Dug well 20 feet in clay; well sometimes dry; in spring the water is up to the surface and is hard.

Section 31.

Felker. Drilled well 65 feet in drift, seldom dry; 5 to 6 feet high in spring.

Helmreich. Drilled well about 130 feet deep; salty water, stopped in sand.

Section 33.

Leinberger. Drilled well 82 feet deep, sand and gravel at the bottom with water; never dry; water used to come 4 feet from the top, lower now.

About one-half of a mile northeast of the southwestern corner. Fifty feet of clay, quicksand for 40 feet, then rock.

In the southwestern part. Eighty feet of clay and no sand; water at about 80 feet.

Section 35.

Deneke. Drilled well 175 feet deep, about 80 feet of clay, 40 to 50 feet of sand; no rock; water 6 feet from the top.

Sturm. Drilled well 90 feet deep; plenty of water.

Center of the N. W. ¼. One hundred seventy-five feet to rock

MT. FOREST TOWNSHIP.

Section 10.

In the S. E. ¼. J. Mansfield. Rock at 92 feet. One flow of water at rock, then by drilling in rock 170 feet got a second and stronger flow. Out of eight holes, five flowed. (See chapter on coal for record of holes).

Section 13.

School house in the S. W. corner. Eighty feet to rock and 145 feet in all; water very constant, 12 feet from the top, no flowing wells near here.

Section 22.

Hudson. In the S. W. ¼ of the S. W. ¼. Dug well 16 feet deep.

Section 23.

J. Hooker. In the S. E. ¼ of the S. W. ¼. Dug 17½ feet and drilled 90 feet to gravel (above rock), water within 12 feet of the top.

Wasielewski. In the N. E. ¼ of the N. E. ¼. No water in his wells, one went 83 feet to rock, and the other to 90 feet. Mt. Forest bed rock at 90 feet. The average depth to rock in Mt. Forest is 87 feet. (?)

Section 26.

Lalonde. In the S. W. ¼ of the S. E. ¼. Dug well 12 feet to water.

Eighty rods east of the S. W. corner. Wilson. Drilled well 107 feet to rock, water 3 feet from the top.

Section 33.

Warren. In the N. E. ¼ of the N. E. ¼. Dug well 10 feet deep, 2 feet of water.

Section 36.

Derren. In the N. W. ¼ of the N. E. ¼. Dug well in clay, 12 feet deep, 6 feet of water.

PINCONNING TOWNSHIP.

Section 1.

A. Valley. In the middle ½ of the W. ½ of the N. E. ¼. Dug 10 feet deep, water near the surface.

Section 3.

G. Stephenson. In the E. ½ of the N. E. ¼. Drilled 35 feet to rock, rose within 5 feet of the top.

Section 4.

In the N. E. ¼. Dug 13 feet in clay, water 6 feet from the top, abundant.

Section 9.

E. Breman. In the S. W. ¼ of the S. E. ¼. Drilled 200 feet deep, no flow; good supply, not mineral.

Section 11.

M. E. B. In the S. ½ of the N. E. ¼ of the S. E. ¼. Dug 15 feet deep, 6 feet of water.

Section 13.

C. Peters. On the E. and W. line (¼) 80 rods W. of the E. ¼ post. Well is brackish, one-half inch stream, 2 feet from top, traces of iron.

Section 14.

Brown & Jennings. In the W. ½ of the S. E. ¼ of the S. W. ¼. Well 50 feet to gravel (above rock?), one-half inch stream, slightly mineral.

Section 15.

B. Stewart. In the S. ½ of the S. E. ¼ of the N. E. ¼; 61 feet to rock 1½ feet in rock, flowed 1.5 feet from the top, not flowing now.

Section 16.

Dolph. In the S. E. ¼ of the N. E. ¼. Drilled 65 feet to rock, cased 10 feet; fresh water flowing steadily.

Legness. In the N. W. ¼ of the N. W. ¼. Dug well 12 feet deep, goes dry.

Tatro, N. In the S. E. ¼ of the S. W. ¼. White sandrock at 65 feet, clay to rock, no flow.

Section 17.

P. Bodrie. In the W. ½ of the S. E. ¼ of the S. W. ¼. Dug well 16½ feet deep, 9 feet of water; went dry one season, good water.

Section 18.

On the E. and W. ¼ line 1-10 of a mile W. of the shore line. Drilled well 50 feet deep, ¼ of an inch stream; rising 3 feet below the top; very salty, traces of iron.

Section 19.

H. Lowe. In the N. ½ of the N. E. ¼ of the S. E. ¼. Seventy-three feet on rock, water 3 feet from the top; clay all the way down.

Section 21.

E. Rentz. In the S. E. ¼ of the S. W. ¼. Dug well 13 feet deep, 7 feet of water.

Section 22.

McLean. In the S. W. ¼ of the N. W. ¼. Drilled well one-fourth of an inch stream, 2.5 inches above the top; slightly mineral.

Section 24.

School house 80 rods west of the S. E. corner. Flowing well, water salty; traces of iron, runs one-half inch stream, flows 2 feet above the surface.

N. Lee. In the S. E. ¼ of the S. E. ¼. Thirty-three feet deep, not to rock; salty, flows one-half inch stream 2 feet above top of well.

S. R. Ballard. Eighty rods N. and 80 rods W. of the S. E. corner. Thirty-eight feet to rock, one inch stream; 2 feet above top, drilled in fall of 1898; salty.

Also dug well 14 feet deep, water fresh; varies from 2 feet in summer to 12 feet in spring.

Section 25.

J. H. Plummer. Eighty rods east of the S. W. corner. Forty feet to rock, 60 feet to water; at 209 feet found 3 feet of coal; flows one-half an inch stream 2 feet high, salt, shows iron.

Section 26.

Near the north quarter post. Porter's. Drilled well 60 feet deep, not to rock; flows 2 feet above, runs one-half inch stream; said to flow 6 feet above, brackish.

Section 27.

D. Dalke. At the S. W. corner. Drilled well 45 feet deep; 3 feet above top—flowing. Eighty rods S. of the N. E. corner. Dug well 25 feet deep, at first 21 feet of water, in 1900, 20 feet.

Section 29.

O. Newman. In the S. E. ¼ of the S. E. ¼. Drilled well spring of 1900. Forty-eight feet deep. Does not flow.

Section 30.

H. A. Mosher. In the S. E. ¼ of the S. E. ¼. Drilled well 85 feet, not to rock; water 1 foot above the surface.

Section 32.

H. Messner. In the N. W. ¼ of the N. E. ¼. Drilled well 47 feet deep in fall of 1899. Water flows over the surface.

G. Schinijuski. In the N. E. ¼ of the N. W. ¼. Drilled well 60 feet deep but not to rock, water just to the surface.

F. Allor. In the N. E. ¼ of the S. E. ¼. Drilled well 45 feet to the water; flows 2. feet above the top of the well.

In the S. E. ¼ of the S. E. ¼. P. O'Keefe. Drilled 56 feet to rock. Sand on rock.

Section 33.

J. Eseltine. In the W. ½ of the S. W. ¼. Fifty-six feet to the rock, flows 2 feet above the top; drilled in 1897.

PORTSMOUTH TOWNSHIP.

Section 1.

Walther. Dug well 16 feet in clay; water 3 feet from the top, never dry, hard.

Section 2.

Chatfields. Rock at 125 feet.

Section 3.

Henry. Dug well, 28 feet deep; never dry; 3 feet from the top, hard.

Section 4.

Cartwright. Dug well 10 feet deep; 3 feet of sand on top, rest clay; never dry, water irony, hard.

Section 5.

Lindner. Dug well 25 feet from the top; never dry, water 2 to 4 feet from the top, hard.
Bublitz. Well 109 feet deep; slightly salty, water 10 feet from the top, never dry; little flow.

Section 6.

Decorte. Dug well 20 feet deep in clay; water 2 to 20 feet down, hard.
Young. Dug well 196 feet deep, 100 feet to rock, clay to rock; salty, water 8 feet from the top, small flow, never dry.

Section 7.

Brandt. Drilled well 135 feet deep, 90 feet to rock; water 5 feet from the top, water fresh, hydrogen sulphide.
Wagner. Dug well 18 feet in clay; water 7 to 8 feet from the top, hard, never dry.
Wilkins. Dug well 20 feet deep in clay; water low in summer; sometimes dry, hard.

Section 10.

Matts. Dug well 16 feet deep. Water to the top in spring, never dry.
Another well 12 feet deep with lots of water always.
On the north line and in the N. W. ¼; 105 feet to rock.

Section 11.

Howard. Dug well 19 feet deep; water 4 feet from the top, never dry, hard.
Gates. Rock at 125 to 130 feet, fresh water at 240 feet.
Gates. Drilled well 241 feet deep; salty, water to the top.

Section 12.

Boes. Dug 65 feet in clay, 10 feet in dry gravel, then 18 feet in sand, then into hardpan.

Section 13.

Seebeck. Dug well 14 feet deep. Plenty of water 4 feet from the top.

Section 31.

Timm. Drilled well 157 feet deep; rock at 90 feet; salty water 9 feet from the top, never dry.
On the north line, ¼ mile E. of the N. W. corner. Dug well 15 feet deep in clay; water 1 to 2 feet from the top, hard.

Section 32.

Koester. Drilled well 251 feet deep; fresh water, 10 feet from the top; rock at 80 feet.

Section 33.

Young. Dug well 6 feet deep in clay; never dry.
Underwood. Dug well 124 feet deep, 90 feet to rock, clay to rock; water 4 feet from the top; hard, salt, never dry.

Section 36.

Wanderwilt. Drilled well 153 feet deep, 91 feet to rock; very little salt; water 6 feet from the top, never dry.

WILLIAMS TOWNSHIP.

2.5 miles N. Auburn rock at 93 feet.
1.75 miles S. Auburn rock at 130 feet.
One mile N. Auburn rock at 124 feet.

Section 2.

Hutchinson. Flowing well 75 feet deep, salty; 4 feet of sandy loam on the top, hardpan the rest of the way; 3 feet of sand and gravel at the bottom with flow, hard.
Sullivan. Flowing well 84 feet deep in drift; small flow, hard; little salty.

Section 3.

Burk. Flowing well 85 feet deep in drift, hard, salty.
Abard. Water 4 feet from the top; 90 feet deep, least salty, hard.

Section 4.

In the east part, Hardy. Put down first flowing well in 1887. Depth 93.5 feet, salty; all in drift, clay and hardpan for 71 feet; then 20 feet of fine sand, then 2.5 feet of gravel which probably rests on rock.
Shurkey. Drilled well 83 feet deep in drift, little salty, hard, drift coal.

Section 5.

Gates. Dug well 26 feet deep in clay; well almost full, never dry, hard.
Forster. Drilled well 72 feet in drift; water 9 feet from the top, never dry, least salty, hard.

Section 7.

Dingman. Dug well 11 feet deep, sand on top, rest clay, hard, never dry.

Section 8.

Arthur. Drilled well 110 feet deep in drift; gravel at 80 feet, clay and hardpan below, then coarse sand with water; water 18 feet from the top, fresh, medium hard.
Near the southeast corner. Kohler. Clay for 90 feet, sand and gravel 30 feet; water at 120 feet, 8 feet from the top, fresh and soft.

Section 9.

J. B. Plant. Drilled well 100 feet deep; water 3 feet from the top, brackish; rock at 85 to 90 feet.
Wm. Plant. Drilled well 23 feet deep; never dry, soft and fresh; all in clay.
Emanof. Drilled well 100 feet deep in drift, water soft, fresh; 8 feet from the top.
Kohler. Drilled well 125 feet deep; 100 feet to rock; water 10 feet from the top, fresh and hard, softer than surface well.

Section 10.

Hopler. Drilled well 90 feet deep in clay, red clay at the bottom. Water 6 feet from the top; hard, very little salty.
Buzzard. Drilled well 82 feet deep, rock at 60 feet—boulder. Water salty, gravel at the bottom, flows 1 foot above the top, hard. In coal hole rock at 100 feet. Vein of coal 18 inches at 165.
At the N. E. corner. Drilled well 74 feet deep in drift; water 4 feet from the top.
Another well 84 feet deep in clay, sand at the bottom; water 6 feet from the top.
Richardson. Drilled well 122 feet deep in drift; 4 feet of sand at 72 feet, clay below; salty water at 120 feet.
Van DePlas. Dug well 25 feet deep in drift, water hard.

Section 11.

Kennell. Flowing well 60 feet deep, salty.
Meyers. Flowing well 68 feet deep, clay down to gravel; flow in gravel, salty. Drilled well 116 feet deep, water almost to top, salty, all in drift.
S. Rowden. Drilled well at 113 feet; rock at 86 feet, water at 80 feet in sand and gravel. Then flow of water to the top at 113 feet.
Pfund. Dug well 17 feet deep in blue clay, dry.

Section 12.

Beattie. Drilled well 112 feet deep, salty, hard; used to flow, clogs with sand.
Carlson. Dug well 14 feet deep in clay, fresh and never dry.

Section 13.

Gartung. Drilled well 67 feet deep in blue clay; water 5 feet from the top; slightly salt, water from sand and gravel bed in the bottom.
On the east line. Rock at 125 feet, clay for 120 feet; water on the top of the rock in sand and gravel; shale on top, coal at 135 feet and 160 feet.

Section 14.

Phillips. Drilled well 99 feet in drift; fresh, hard, 7 feet from the top.

Section 15.

Horn. Dug well 12 feet deep in clay and gravel, hard, sometimes dry in summer.
Well at Auburn near the depot. Clay 80 feet, sand 138 feet with drift coal, then 2 feet of gravel with water; little salty and hard; blue shale at 220 feet.
Hotchkiss. Drilled well 112 feet deep in clay and gravel. Water salty, at first 9 feet from the top, farther now.

Section 16.

C. Kindell. Dug well 16 feet deep in clay; dry in August, hard and fresh.

Section 17.

Kraus. Dug well 18 feet deep in drift; dry in summer of 1899; soft.
Twenty-six chains south of the northwest corner. Dug well 10 feet deep almost all in sand; soft water, never dry.

Section 18.

J. B. Mathews. Dug well 14 feet all in clay and gravel, hard and fresh.

Section 19.

Berger. Dug well 16 feet deep, sand and clay below. Never dry, hard.

Section 22.

White. Dug well 22 feet deep. Never dry, hard.

Section 23.

Kent. Drilled well 60 feet deep in drift; water 7 feet from the top, hard and fresh.
Keher. Dug well 17 feet deep in clay (sandy), dry in summer of 1899. Hard and soft.

Section 24.

O. Rosekrans. Drilled well 82 feet deep, sand in the bottom, fresh and hard.

Section 25.

In the eastern part. O'Connor. Dug well in clay, 13 feet deep, hard, never dry.
Cagwin. Drilled well 85 feet deep in drift; water 7 feet from the top, hard and fresh.
Hemmingway. Drilled well 125 feet deep in drift; water hard, fresh, 8 feet from the top.

Section 26.

Swartz. Drilled well 122 feet deep in drift; lots of water, fresh and hard.

Section 27.

Eddy. Dug well 12 feet deep, 4 feet in sand on surface, rest clay; never dry; 6 feet from the top in summer of 1900.

Section 28.

In the S. ½ of the S. E. ¼. One hundred eighty-seven feet to rock, 175 feet clay and sand below.

Section 32.

Fischer. Dug well 10 feet deep in sand and clay. Well dry in summer, hard.

Section 33.

Dalrymple. Dug well 12 feet deep in clay; hard, never dry; 6 feet of water in the well.

Section 34.

Bierd. Drilled well 143 feet deep, 80 feet of clay on the top; water 30 feet from the top; hard and fresh.

Section 36.

Terry. Drilled well 59 feet deep, clay for 52 feet, 7 feet of gravel at the bottom; water 7 feet from the top, soft, never dry, stationary.

LAKE SUPERIOR
DOMINION OF CANADA
WISCONSIN
LAKE MICHIGAN
LAKE HURON
SAGINAW BAY
ILLINOIS
INDIANA
OHIO
CANADA
LAKE ERIE

AN ILLUSTRATED CATALOGUE

OF THE

MOLLUSCA OF MICHIGAN

BY

BRYANT WALKER

PART I.

TERRESTRIAL PULMONATA

(LAND SNAILS)

Published by the State Board of Geological Survey, as a part of the Report for 1905, and as a contribution to the Biological Survey of the State, authorized by Act 250, Session 1905

LANSING, MICHIGAN
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1906

LETTER OF TRANSMITTAL

OFFICE OF THE STATE GEOLOGIST.

LANSING, MICHIGAN, Jan. 22, 1906.

To the Honorable, The Board of Geological Survey of the State of Michigan:

Hon. Fred M. Warner, President.
Hon. W. J. McKone.
Hon. Patrick H. Kelley, Secretary.

Gentlemen:—I herewith transmit for publication as part of your report a contribution to the Biological Survey of the State, authorized by Act 250 of the Session of 1905, a paper by Bryant Walker, Esq., of Detroit, on the Terrestrial Mollusca,—the land snails and garden slugs,—of the State.

Through the generosity of Mr. Walker in illustrations, we are able to show not only the counties in which the different species have so far been found, but figures by which they may be identified.

Mr. Walker has also given references to the names by which they have been known, and the different authors, who have treated them.

Very respectfully,

ALFRED C. LANE,
State Geologist.

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PREFACE.

In an endeavor to compile a complete census of the mollusca of Michigan, the Conchological Section of the Michigan Academy of Science has found the lack of convenient and accessible literature a most serious obstacle to enlisting the interest of the many teachers and students of biology throughout the state.

The present catalogue has been prepared in an attempt to supply this want and to furnish a convenient manual, which would not only embody the recent advances in systematic conchology and exhibit the extent of our present knowledge of the fauna of the state and its distribution, but also enable the student to identify his specimens with some reasonable degree of certainty.

The systematic portion of the work has been adopted *verbatim* from Pilsbry, Crosse and Fischer, and other recognized authorities. The specific descriptions have been prepared with a view to emphasize the distinctive features of the different forms, and in all cases keys have been supplied as an additional assistance.

Through the courtesy of the Secretary of the Smithsonian Institution, electrotypes of the excellent figures contained in the various manuals published by the Institution have been obtained. Other figures as far as possible have been copied from authoritative sources and, where both of these failed, original figures have been prepared.

In the matter of synonymy, the scope of the work is such as to preclude the full presentation that would be expected in a complete monograph. In addition to the citation of the original authority, however, reference has been made to Binney's Manual of American Land Shells, where full details in this particular will be found as to all except the most recently described species. It has also been deemed desirable to include references to the several general catalogues that have been published of the mollusca of the state.

The writer is under many obligations to the members of the Michigan Academy of Science, for valuable material showing the distribution of the different species, and especially to Dr. A. C. Lane and Mr. W. F. Cooper of the State Geological Survey, Mr. R. H. Pettit of the State Agricultural College, Prof. C. A. Davis of the State University, Dr. R. J. Kirkland and Mr. L. H. Streng of Grand Rapids, Sister M. Catherine of St. Mary's Academy, Monroe and Dr. P. E. Marsh of Otter Lake. We also are indebted for much kindly assistance and suggestion, to Dr. H. A. Pilsbry of Philadelphia, and Mr. George H. Clapp of Pittsburg, Pa., and Dr. V. Sterki of New Philadelphia, Ohio.

Several important changes in nomenclature having been made since the paper was submitted for publication, advantage has been taken of the delay in printing to incorporate them and other additional data recently received, thus bringing the subject down to date.

Detroit, September 1, 1906. BRYANT WALKER.

AN ILLUSTRATED CATALOGUE

OF THE

MOLLUSCA OF MICHIGAN.

INTRODUCTION.

I.

REVIEW OF MICHIGAN CONCHOLOGY.

Barring a few scattering descriptions by European naturalists of such species as were brought home by the early travellers in this country, the history of North American conchology may be said to have begun when Thomas Say, in 1817, wrote the article on "Conchology" for the first American edition of Nicholson's Encyclopedia of Arts and Sciences. Philadelphia then, as now, was the centre of activity in this branch of science in the United States, and in the proceedings of the then newly organized Academy of Natural Science and a few other scientific and literary publications of that city, nearly all the conchological writings for the next twenty years are to be found.

The first record of Michigan conchology was made in 1822, when Thomas Rackett, an English naturalist, in the Transactions of the Linnean Society of London, published a list of seven species of shells collected near Thunder Bay, Alpena county. One of these, *Polygyra monodon*, still bears the name which he gave to it.

Michigan, as such, had no distinctive name in those days, and was known only as a wilderness filled with swamps and savages and located somewhere in that still greater and more indefinite region called the northwest.

But as population increased and young blood from the New England states made itself felt in the new territory, there began a dawn of better things. And one of the first acts of the first legislature of the new state of Michigan in 1837 was the establishment of a State Geological Survey with Douglass Houghton at its head as Geologist and Dr. Abram Sager as Zoölogist. Dr. Sager, who in after years became so well known in the Medical Department of the State University, and, who had already in 1836 supplied Conrad with material for his monograph of the *Unionidæ*, entered with activity upon the duties of his position and in 1839 published the first paper upon Michigan conchology. It is simply a list of species, 76 in number, one of which was not identified. It is dated January 12, 1839, and is to be found in the Documents of the House of Representatives for 1839 at page 410.

In 1859, the Legislature passed an Act entitled "An Act to finish the Geological Survey of the State." The late Prof. Alexander Winchell was appointed State Geologist and Prof. Manly Miles State Zoologist.

The first report bears date December 31, 1860. It contains in addition to other faunal lists, a catalogue of 161 species of shells, two of which *Planorbis truncatus* and *Unio leprosus* are described as new.

In the years, which had intervened between the publication of these catalogues, in addition to such scientific activity as centered around the labors of Dr. Sager and Prof. Winchell at the university, a little band of active collectors residing at Grand Rapids had done much to develop the fauna of the western part of the state. Alfred O. Currier, John A. McNeil, W. H. DeCamp and L. H. Streng were the leaders.

Mr. Currier came to Grand Rapids in 1850 from Troy, N. Y., where he had become fascinated with the study of conchology from being associated with that eminent conchologist, the late Dr. Wesley Newcomb. He died in 1880 and his extensive collection became the property of the Kent Scientific Institute of Grand Rapids. He published in 1859 (?) a "List of Shells Collected in the Grand River (Mich.) Valley," and in 1865 a "Catalogue of the Mollusca of Grand Rapids, Michigan." In 1867 he published descriptions of four supposed new species from this state in the American Journal of Conchology, III, p. 112. In 1868 he published as No. 1 of the Miscellaneous Publications of the Kent Scientific Institute, an elaborate "Catalogue of the Shell-bearing Mollusca of Michigan." This list was by far the most complete yet published and enumerated 171 species and 6 varieties.

Dr. DeCamp came to Grand Rapids in 1855. In the congenial company of Mr. Currier he turned aside from botanical and geological work, which had previously enlisted his attention, and from that time devoted his leisure hours almost wholly to the study of our local mollusca. He accumulated a large and valuable collection, and his time and specimens were always at the service of his fellow collectors. In 1881, Dr. DeCamp, under the auspices of the Kent Scientific Institute, published a "Catalogue of the Shell-bearing Mollusca of Michigan," in which, in addition to the list of 221 species and 9 varieties, he figured and described three species named by Mr. Currier, but never formally described. He died in 1898.

In 1856, Mr. John A. McNeil settled in Grand Rapids, and became interested in the subject through Mr. Currier and Dr. DeCamp. He remained there as an active and indefatigable collector until 1870, when he left and made collections in Central and South America a specialty. He died about 1891 at Binghampton, N. Y. I am not aware that Mr. McNeil ever published anything upon his Michigan collection. But Prof. Miles acknowledges the assistance afforded by him in the preparation of his catalogue, and Mr. Anthony was also indebted to him for some of the material from which he described a number of Michigan species, and, indeed, named one of them after him.

Mr. Streng, who has been a resident of Grand Rapids since 1870, began to collect as far back as 1850, when a resident of Saugatuck and is still engaged in the pursuit of his favorite study. The writer has elsewhere had occasion to express his obligations to Mr. Streng for much generous assistance in compiling his previous catalogues of the shells of the state.

In 1879, the writer published a "Catalogue of the Shell-bearing Mollusca of Michigan" in the Journal of Conchology, in 1892 a second list in the Nautilus, and a third in 1894.

In addition to the two papers by Mr. Currier, already referred to, the following local lists have been published:

In 1872–3, Mr. Sidney I. Smith published "A Sketch of the Invertebrate Fauna of Lake Superior."

In 1876, Mr. C. E. Beecher and myself compiled for the Ann Arbor Scientific Association a list of the species found in that vicinity.

And in 1893, I published "A List of the Shells of the Saginaw Valley," based upon the collection of the late Dr. George A. Lathrop, and in 1896 a "Report upon the Mollusca Collected in the Vicinity of Charlevoix."

In 1904, Mr. A. G. Ruthven published a list of the Mollusca of Ontonagon county. And in 1905 in connection with the writer a further list of the Mollusca of Ontonagon County and those of Isle Royale.

The following papers have also been published by the writer on special subjects of investigation.

"The Distribution of the Unionidæ in Michigan" (1898), "The Terrestrial Mollusca of Michigan" (1899) and "The Distribution of Polygyra in Michigan" (1905); in 1905 a synopsis of the fauna as known at the present time.

In addition to these papers which are devoted entirely to the shells of the state, many scattering references to our fauna are to be found in the writings of nearly all the prominent conchologists of this county. A full list of these will be found in the bibliography appended to the concluding portion of this paper.

In 1894, the Michigan Academy of Science was organized and the very considerable advances made in knowledge of the molluscan fauna of the state within the last decade have been due, to no small extent, to the influence of this organization in stimulating hearty co-operation among its members. The Section of Conchology was organized in the spring of 1896 with thirteen members. Steps were taken at once to prepare a complete census of the Michigan Fauna. This involved:

First. The compilation of all the records of every species known or cited from the state up to that time, and:

Second. Such additions from year to year as the field work of the members might supply.

The first requirement was accomplished in due time and the second has been very faithfully carried out by most of the members. The work of the Section has naturally developed in two lines:

First, The authentication or disproof of the actual occurrence within the state of all species previously accredited to our fauna and the addition of such new species as were found.

Second, The extension of our knowledge as to the distribution of the different species through the state.

The result of this systematic endeavor has, in the aggregate, been very large, and the completeness of the present catalogue is to no small extent due to the members of the Section.

The growth of our knowledge of the molluscan fauna of the state during the sixty-six years which have elapsed since the first catalogue was published is shown by the following synopsis of the number of species listed in catalogues of Sager (1839), Miles (1860), Currier (1868), DeCamp (1881), Walker (1894), and Walker (1905). In arranging it all those species, whose occurrence in the state is considered doubtful for reasons hereinafter given, and all synonyms and varieties have been eliminated.

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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] dividing line.

[illegible] *Zonitoides*

[illegible] them. They are:

Pyramidula rupestris haldemani (Binn.)	*Vitrea harmonia* (Stein.)
Punctum pygmaeum (Drap.)	*Vitrea indentata* (Say).
Helicodiscus parallelus (Say)	*Zonitoides nitida* (Müll.)
Vallonia pulchella (Müll.)	*Zonitoides arborea* (Say).
Pupilla muscorum (L.)	*Zonitoides minuscula* (Binn.)
Succinea futilis (Müll.)	*Zonitoides milium* (Mse).

Of the species enumerated by the same author as characteristic of the Northern Region twelve are represented in our fauna, viz.:

[illegible] making the present number 70. In this table the species of *Carychium* are included in the [illegible]

[illegible] Under the recent revision of this genus by Pilsbry this species would scarcely fall within this [illegible]

Vitrina limpida Gld.
Vitrea binneyana (Mse).
Vitrea ferrea (Mse).
Vitrea multidentata (Say).
Zonitoides exigua (Stimp).
Acanthinula harpa (Say).
Pyramidula asteriscus (Mse).
Vertigo gouldii Binn.
Vertigo bollesiana (Mse).
Vertigo ventricosa (Mse).
Cochlicopa lubrica (Mull).
Sphyradium edentulum (Drap).

Five of these have apparently a general distribution over the state, viz.:
Vitrea multidentata (Say).
Vertigo gouldii Binn.
Vertigo ventricosa (Mse).
Cochlicopa lubrica (Mull).
Sphyradium edentulum (Drap).

Vitrea binneyana (Mse). and *Zonitoides exigua* (Stimp.) have both been reported from Kent county. This, however, is the only locality reported for either of these species south of the line of Wexford and Iosco counties. *Vitrea ferrea* has been found in Gratiot county. With these exceptions, the remaining five boreal species have thus far been found only in the northern counties of the lower peninsula and in the upper peninsula. That is a distribution agreeing substantially with the delineation of the boreal region by Merriam.

Two species, *Vitrea cellaria* and *Agriolimax agrestis* are European species which have been locally introduced in recent years.

The remaining fifty-five species comprised in our fauna, belong to the Interior Region of Binney, which corresponds substantially with the Transition and Upper Austral Life Zones as established by Merriam. Of these, twenty-six species have a general distribution, at least as far north as the eastern extremity of the upper peninsula. One, *Polygyra sayana* (Pils.), is apparently restricted to the northern part of the lower peninsula, but on the east coast comes down as far south as Tuscola and Huron counties. Another, *Pallifera dorsalis*, has only been found as yet, in Marquette county and Isle Royale; while the remaining twenty-seven species have not, as yet, been reported from north of the Saginaw-Grand valley, except *Polygyra monodon* and *Gastrodonta intertexta*, which range northeasterly into the "Thumb" (Huron, Tuscola and Sanilac counties); and *Omphalina inornata*, which has been reported from Oceana county.

Of the thirty-two species given by Binney as of the Northern Region, eight are peculiar to Greenland and Alaska. Of the remaining twenty-four, twenty have been found in Michigan. While of the sixty-nine species belonging to the Interior Region fifty-three are known to inhabit this state. That is of seventy-two Michigan species, twenty, or a little more than one-third belong to the northern fauna and fifty-three to the interior fauna. The addition of the few species not included in Binney's list would not perceptibly change the proportion. This is what would be naturally expected from the position of the state upon the northern border of the Interior Region and its very considerable longitudinal extent.

The eighty-one species included in the present catalogues are divided among twelve families and twenty-five genera as follows:

Family.	Genus.	Subgenus.	Section.	No. of species.
Helicidæ	*Polygyra*		*Triodopsis*	14
			Stenotrema	3
Circinariidæ	*Circinaria*			1
Zonitidæ	*Omphalina*			2
	Vitrina			1
	Vitrea		*Vitrea s. s.*	4
			Striatura	1
			Glyphyalina	2
			Paravitrea	1
	Euconulus			2
	Zonitoides		*Zonitoides s. s.*	2
			Pseudohyalina	4
	Gastrodonta			4
Limacidæ	*Agriolimax*			2
Philomycidæ	*Philomycus*			1
	Pallifera			2
Endodontidæ	*Pyramidula*	*Patula*		2
		Gonyodiscus		2
		Planogyra		1
	Helicodiscus			1
	Punctum			1
	Sphyradium			1
Succineidæ	*Succinea*			3
Pupillidæ	*Strobilops*			3
	Acanthinula		*Zoogenites*	1
	Pupoides			1
	Pupilla			1
	Bifidaria		*Privatula*	1
			Albinula	2
			Vertigopsis	2
	Vertigo		*Vertigo s. s.*	6
		Vertilla		1
Valloniidæ	*Vallonia*			3
Cochlicopidæ	*Cochlicopa*			1
Auriculidæ	*Carychium*			2
				81

While it is possible that some of the species quoted by the earlier writers as occurring in Michigan but which have not been recognized by later collectors and have therefore been dropped from the present catalogue may hereafter be found within our borders, and that new or additional ones may be reported, yet it is not probable that the present list will be largely increased.

But, while in this particular our fauna can be said to have been well developed, our knowledge as to the distribution of the different species is lamentably deficient. I have indicated on the accompanying chart (Plate I) the number of species which have been reported from each of the counties of the state. From this it will be seen how small a part of the state has been collected over with any sort of thoroughness. Of the fifteen counties in the upper peninsula, eight are not represented by even a single reported species, while of the sixty-eight counties of the lower peninsula, the

fauna of nineteen, or nearly one-third, is entirely unknown; twenty-one are represented by less than ten species; eleven by from ten to twenty species, and only seventeen by more than twenty, nine by more than thirty, two by more than forty, and one by more than fifty. Kent is the banner county with sixty species to its credit. When it is considered that all of the southern counties have, in all probability, as large a fauna as is now reported from Kent, and that the species reported from Charlevoix and Chippewa counties range through the entire northern part of the lower peninsula, the poverty of our knowledge and its entire inadequacy for anything like positive statements in regard to the distribution of the different species is only too obvious.

The great extent of unknown territory in the center of the state north of the Saginaw-Grand valley is especially noticeable and is particularly unfortunate. The Saginaw-Grand valley and the counties lying south of it, and the Grand Traverse region, have been sufficiently explored to give a substantially accurate knowledge of their fauna as a whole. But with this great stretch of unexplored territory lying between them, the northern extension of the species peculiar to the one, and the southern range of those characteristic of the other are wholly unknown, and any attempt to discuss the reason underlying their distribution is necessarily futile when the facts of distribution themselves are wholly conjectural.

All that can be done now is to state such facts as to the general distribution of the fauna of the state as are shown by the returns of the census (Plate II), noting any apparent peculiarities of the range of the different species and leave any systematic discussion of the subject to such future time as our increased knowledge will justify the attempt.

Of the ultimate origin of our fauna, but little is known. The geologists tell us that the terrestrial mollusca range back in time certainly as far as the Carboniferous age and possibly into the Devonian. Indeed, the fact "that their diversity of form gives sufficient indication that the *Helicidæ* had become widely differentiated during those early epochs in which they lived, probably quite as widely as their living representatives are, and under closely similar forms"* would indicate that their separation from their fluviatile or marine ancestors must have occurred at a much earlier date.

A very large part of our fauna is peculiar to North America, and has undoubtedly descended from those ancient forms, which peopled the shores of the great Mezozoic sea and hid under the bark of the fallen giants of the Carboniferous forests. Whether these early mollusca had spread into the Michigan of that day is not known. It seems entirely probable, but there is as yet no evidence either to prove or disprove the existence of such a fauna in this region prior to the Glacial epoch.

But, however that may be, the immediate source of our present fauna must be sought in the states lying to the south and beyond the reach of the ice sheet, which in the Glacial period buried Michigan under hundreds of feet of ice and utterly exterminated every form of molluscan life that may have previously existed here. The extensive Post-pliocene deposits in the Mississippi valley prove conclusively that the fauna then existing was substantially the same as is now found in that region. With the retreat of the ice, the mollusca returned to the north and repeopled the new land. It seems probable that even the so-called circumpolar species, which probably originated in the old world, had made their advent into America prior to the Glacial period, during some earlier age, when a milder climate in the ex-

* White, Review Non-Marine Fossil Mollusca of N. A., p 445.

treme north was more favorable to their introduction and dispersion. The fact that three of the seven specimens common to both continents occur fossil in the loess of Iowa, and another, *Vitrea hammonis* (Ström), has been found associated with the remains of a mastodon in Berrien county in this state, would seem to substantiate this theory.

The following species have been found in the Post-glacial deposits in this state:

Polygyra albolabris maritima (Pils).
Polygyra thyroides (Say).
Polygyra monodon (Rack).
Pyramidula alternata (Say).
Vitrea hammonis (Ström).
Vitrea indentata (Say).
Euconulus fulvus (Dr.)
Zonitoides minuscula (Binn).
Zonitoides arborea (Say).
Helicodiscus parallelus (Say).
Strobilops labyrinthicus (Say).
Succinea retusa Lea.
Bifidaria tappaniana (C. B. Ads).
Vertigo ventricosa elatior Sterki.
Vertigo morsei Sterki.
Vertigo gouldii Binn.
Carychium exiguum (Say).

III.

HINTS ON COLLECTING MOLLUSCA.

The collector should always bear in mind:

First That a dead shell is better than none at all.

Second. That dead shells should not be taken, if live ones can be had and that careful search will usually discover them wherever their "bones" are found.

Third. That all the species are extremely variable in their abundance from year to year, so it is a safe rule "when you're getting, to get a plenty."

COLLECTING APPARATUS.

For land shells, a "Ferriss" hoe is indispensable. This is made by getting a small, light-handled garden hoe and having the blade cut down at a machine shop. It should be about three inches wide on top and taper to a sharp point. Then cut off the handle so that it will be as long as a cane. This makes a most convenient tool for turning over logs and breaking up rotten wood, digging around stumps and among the dead leaves, and in a snake country is very effective for killing rattlesnakes. A pair of fine curved-pointed collecting forceps is also necessary for picking up the small species. Small glass or wooden bottles should be carried, as the small species are apt to get lost in the dirt and slime, if put into the same receptacle as the larger ones. It is better not to put the small species in alcohol as they are collected, as they are then killed at once with the animal more or less extended. If put in a dry bottle and left a few hours they will withdraw into their shells, leaving the aperture clear and fit for examination. This is especially necessary with the *Pupillidæ*, where the arrangement of the apertural teeth is a specific characteristic.

For the larger species tin cases of a convenient size to slip readily into the coat pockets are most convenient. Where the larger *Helices* are so abundant as to make it annoying to have to take the cover off continually, it will be found convenient to have a square hole cut in the cover large enough to pass a snail through. Then stretch a piece of thin rubber, such as a piece of bicycle-tire lining, across the top of the can, and put the cover in place so

as to keep it stretched tight. A slit in the rubber corresponding to the hole in the can will enable one to slip the snails into the can, and the elasticity of the rubber will keep them from getting out again. A few leaves should be put into the cans before starting out to prevent the shells from being injured by rolling around inside. As the cans become full, the leaves can be removed. Several boxes and a number of vials should always be carried, so that specimens from different localities may be kept separate.

For the fluviatile species it is necessary to have a dipper and, if possible, a small dredge. The dipper is made from an ordinary tin one, by removing the bottom and substituting one of fine wire cloth. By removing the end of the handle the dipper can be slipped on to the end of a cane or pole when in use. This is useful not only for reaching the larger specimens from the shore or boat, but especially for sifting the mud and sand from the bottom, where a multitude of small species live, which otherwise would not be found. It will be found more convenient to empty the contents of the dipper, when thoroughly washed out, into a pail and carry the whole mass home before undertaking to pick out the shells. If attempted in the field, many of the smaller and more desirable things are apt to be overlooked. By spreading the mass out in the sun for a short time it will become dry and friable so that the shells can be easily separated and picked out. An ordinary reading glass is very useful for the detection of the more minute forms in sorting over such material.

Many desirable species live in water too deep for the convenient use of the dipper, and for these it is necessary to have a small dredge. One with an aperture of 9 x 6 inches is as large as can satisfactorily be used by a single person in a row boat.

Care must be taken to keep the more fragile species separate from the heavier ones, otherwise they are apt to be damaged in carrying the can about.

KIRKLAND'S COLLECTING APPARATUS.*

Scoop.—A common, tin, cylindrical oblique-topped flour sieve with handle. Remove the wire stirring-device and solder up the holes for its axis. Strengthen attachment of handle to body by soldering additional braces between the two. Get more rigidity by winding brass wire around body, soldering the strands from ½″ to 1″ apart.

Collecting Bag.—*First:* At a corset factory procure a square yard of the material used for making summer corsets, with a square or triangular mesh, fine enough to retain the smallest specimens and coarse enough to permit escape of sand and mud. With strong linen thread make a double seamed bag with rounded bottom. This bag will be approximately 12″ in diameter.

Second: Get a piece of ½″ mesh, galvanized-iron wire netting 11″ square, and tack it with staple tacks to a wooden frame 11″ square, made of pine 2″ wide and 1″ thick. To prevent ends of wire catching in or tearing the outer bag, thin strips of wood 1″ wide are nailed around the frame so as to cover wire ends.

Make another bag of denim 18″ to 20″ deep, just large enough to fit the wooden frame. Tack one end of this bag around the frame with large headed tacks.

Insert this second bag within the first and fasten the tops together with four or five strong safety-pins.

* Prepared by Dr. R. J. Kirkland of Grand Rapids, Mich.

This double bag apparatus can be carried in one hand, scoop in the other, and employed around springs, creeks, etc., whenever a patch of alluvium is seen, where *Pisidia* and other mud-loving species are likely to be found. The inner bag will prevent vegetation, dead leaves and sodden twigs from passing through into the outer one. When the bag is sufficiently heavy, carry to water that is deep enough to permit it being soused up and down.

Wash out everything that will pass through the inner bag and remove it. Then continue sousing until all sand and mud is washed away. The comparatively small volume of material remaining may be partly or wholly emptied into the scoop and, by careful immersion, agitation, raising and lowering, the greater portion may be floated off, leaving the residue consisting of pebbles and shells at the bottom. Empty these into a small sack, and repeat procedure until satisfied with catch.

When ready for home, empty contents of small sack into scoop and float off still more debris. At home take a piece of ¼″ mesh wire netting 4″ or 5″ square, concaved with fingers, and remove large pebbles. Put remainder into a dish and cover with alcohol. Let this stand for some hours, then spread out thinly on a newspaper, allowing the material to become thoroughly dry. The alcohol not only kills the animal, but hardens the tissues and contracts the muscles, so that comparatively few have gaping valves later. With a jeweler's loupe and a pair of forceps the final separation may be made when convenient.

Frequently one will have large numbers of other shells: *Amnicola*, *Valvata*, *Paludestrina*, and an occasional *Bifidaria* or *Vertigo*. The inner bag may be dispensed with when dead leaves and twigs are not abundant, and then one will find some of the booty consisting of *Planorbis*, *Physa*, and *Lymnæa*.

WHERE TO COLLECT.

Everywhere. The land species love dampness and darkness. They are to be looked for under logs, bark and leaves in suitable localities. Many species bury themselves in rotten logs, and these should be broken up with the hoe. The accumulation of dead leaves around fallen trees is a favorite habitat and should also be carefully and slowly gone over with fingers and hoe. The thick grass and dense thickets along the margin of ditches and streams will usually reward a careful examination. Southern and western exposures being dryer, are not so fruitful as eastern and northern hillsides and shady ravines. Coniferous forests are usually quite barren of molluscan life. An open hardwood forest in a limestone region is the ideal hunting ground. Nearly every permanent body of water has its mollusks, varying according to its character. Some species are found only in rapid flowing water, and others only in ponds and still water. Ditches and other stagnant waters are usually good collecting ground for *Pisidia* and other small species. The low places in the woods, which dry up in the summer time, have a number of species that are not found elsewhere, and which bury themselves in the mud when the water disappears. Sand banks in rivers and lakes are the favorite resort of many of the smaller species. The under side of the lily pads should be scrutinized, while the *Ancyli* should be looked for on stones and dead clam shells.

CLEANING AND PREPARATION OF SPECIMENS.

The larger *Helices* should not be put into alcohol unless desired for anatomical purposes, as it is almost impossible to remove the animal after it has become hardened. They should be boiled as soon as possible. Dead snails have a fragrance peculiar to themselves, and seldom make good specimens. The water should be boiling, not simply hot. Species of about the same size should be boiled together in order that the operation may be successful. A small wire strainer with a long handle is very convenient for holding the snails while boiling. If dropped directly into the water, there is apt to be trouble in fishing them out and they are likely to be boiled too much. The time varies according to the size and the species, some requiring more time than others. If not boiled enough, the muscular attachment to the shell will not be loosened, and the animal will not "pull" at all. If boiled too long, it is apt to break in two and give a good deal of trouble before extraction. The time required varies from ten seconds for a species of the size of *Polygyra monodon* to sixty seconds for *P. albolabris*. It is well to experiment a little at first with a specimen or two of each kind until the proper time is found. Only a few should be boiled at a time, as they "pull" easier while warm. When boiled, the animal should be slowly and carefully pulled out. Too much haste is apt to cause the animal to break apart, leaving the apical whorls still in the shell. The curved points of the collecting forceps are convenient for extracting the animals and hooks of various sizes can be made from safety pins. By tying these on to small wooden handles very effective instruments can be made. Small hooks of various sizes fitting into an adjustable handle are most convenient and can be obtained from any dealer in dental instruments. A small, fine-pointed, dental syringe is indispensable for this work. If the animal cannot be started with the hook, or if it breaks in two, a jet of water from the syringe will usually solve the difficulty. When the apical whorls are left in the shell, they can sometimes be started by holding the shell carefully in hand so as not to crush it, and then striking the fist sharply on the thigh of the operator. In case very desirable specimens get into this predicament, putting them in alcohol for twenty-four hours will contract the remnant of the animal sufficiently to enable the successful use of the syringe. Many of the species have the aperture so obstructed with teeth, that it is difficult to extract the animal with the hook. In such case a vigorous use of the syringe will force enough of the body out of the shell to enable the hook to be used. Frequently the whole animal can be forced from the shell in this way, especially in the smaller forms. Patience and perseverance will clean nearly every specimen. When the animal is completely extracted the interior should be thoroughly washed out with the syringe. A small piece of sponge on the end of a fine copper wire, which can be bent in any direction, is very useful for removing the mucus, which is apt to adhere to the interior of the shell. This should always be carefully attended to, as it will greatly disfigure the specimen when dried. The exterior should then be thoroughly scrubbed with a soft tooth or nail-brush. When perfectly clean, inside and out, the water should be carefully emptied out and the shell put aside in the air, but not in the sun, to dry. No oil or acid should be used on any of the land shells. It is not desirable to attempt to clean the small species by removing the animals. By keeping them for a short time in a dry place, the animal will retire far within the shell. Then they should be put into 25 per cent. alcohol for a day or two. If to be left longer in the alcohol, the strength

should be increased. Twenty-four hours, however, in the alcohol is all that is necessary. Then they can be dried in the air without leaving any offensive odor. Either before or after drying they can be cleaned by putting them in a bottle with some fine, clean sand and shaking them together until all the dirt has been removed by the sand.

Specimens of land snails desired for anatomical purposes should be drowned before being put into the alcohol or formaldehyde, otherwise they retire as far as possible within the shell and are more difficult to dissect in this contracted condition. By drowning, they die fully extended and can then be put into the preservative. It takes about a day to kill a snail in this way. The alcohol at first should be greatly diluted, not stronger than 25 per cent., after a day or two the specimens should be removed to 50 per cent. alcohol, and later to the undiluted. Formaldehyde, 2 per cent. dilution, is an admirable preservative for material of this kind. It should not, however, be used when it is desired to keep the shells as specimens as it destroys them if left in it any length of time.

With the exception of the larger species of *Planorbis*, which are more easily cleaned by boiling, it is practically immaterial whether the fluviatile univalves are boiled or put directly into diluted alcohol. In either case there is no difficulty in extracting the animals. The minute species are treated the same as the small land shells. In the operculate species, it is desirable to retain the opercula of, at least, part of the specimens. While it adds to the labor, it increases the value of the specimen, if it is always done. These are easily removed from the animal and, after being cleaned, should be put inside the shell and the aperture plugged with cotton. All the foreign matter both inside and outside of the shell should be removed by thorough washing. All the water species are apt to be more or less incrusted with deposits of lime or oxide of iron. These can be removed by immersing them in oxalic acid. Care should be taken not to prolong the operation, or the texture of the shell may be injured. Elbow grease is the most effective agent for making good specimens. When that fails, use the acid. The *Ancyli* are always more or less coated in this way, and can easily be cleaned by floating them for a few seconds on the acid, upside down, and then gently brushing them off with a soft brush while held on the tip of the finger.

The larger bivalves should be well washed and, if necessary, scraped off with the knife as soon as taken, care being taken not to injure the epidermis.

They can be boiled, if desired, when the shells will open and the animals easily removed. But as a rule it is more convenient to cut the muscles, which hold the valves together, with a thin bladed knife and scrape the animal out. Care should be taken not to break the edge of the fragile species when inserting the knife. All traces of animal matter should be removed, and after a thorough washing the valves tied together with a string until thoroughly dried. Never use colored twine for this purpose, as it is apt to stain the shells. Any surface incrustation can be removed either with oxalic or muriatic acid. The latter is more convenient for the larger species, and can be applied with a small brush. It does not bite the fingers, so that it can be used freely. Care, however, must be exercised in using it and the specimens frequently washed, lest damage be done to the shell. The smaller bivalves, the *Sphæria* and *Pisidia*, are best treated by putting into diluted alcohol for a day or two and then drying them. If left too long the shells are apt to open, which interferes with the looks of the specimens.

The larger species of *Sphærium* are better with the animal removed. This

can be done after boiling, or a few days in alcohol. As these are usually too small to be easily tied together to keep the valves from gaping, each specimen, while the hinge is flexible, should be closely wrapped up in a small piece of tissue paper until completely dry.

While it is not usually desirable to keep "dead" shells for the cabinet, occasionally it is necessary. In such cases, the color can be in some measure restored by washing in a solution of paraffine and gasoline (a square inch of the former in half a pint of the latter).

A good collection is characterized by two essentials:

First. The careful selection and preparation of the specimens themselves.

Second. Absolute accuracy in the matter of the localities from which they come.

There is little excuse for having poor and ill-cleaned specimens. There is none at all for failure to keep accurate records of the collector's field work. A drawer of a common species, such as *Polygyra albolabris*, without any indication from where they came, even if well cleaned, would be absolutely without value. Such a drawer of any of our species from fifty or one hundred different localities, definitely indicated, would be a valuable contribution to the conchology of any state.

Specific names can be supplied or corrected any time, but a mistaken or erroneous locality cannot ever be corrected. The collector therefore should be careful never to trust to memory for facts of this kind.

Both in collecting and cleaning, the specimens from each locality should be kept carefully separated and labeled. Too much importance cannot be given to this point. The study of the geographical distribution of the mollusca is one of the most important branches of conchological work, and this, to be of any value, must be based on absolutely accurate work on the part of the collector.

ARRANGEMENT OF THE COLLECTION.

The manner of casing and arranging the collection is largely one of individual preference. A catalogue, however, is essential, and it is better to begin systematically in this particular and thus avoid the necessity of doing it all over again, when the collection begins to assume considerable size. There should be a serial catalogue and a card catalogue. Each addition to the collection should be numbered as soon as received and entered in the serial catalogue, which should be a book ruled in as many columns as the collector desires. A convenient form is as follows:

Serial No.	No. of Spec.	Name.	From whom Received.	Locality	Remarks.
1	5	Polygyra albolabris (Say).	John Jones	Ann Arbor, Mich.	

The card catalogue is convenient in a small collection. It becomes absolutely necessary in a large one.

The cards should be of uniform size for convenience in handling. If it is

desired to have a card for every entry, they can be smaller than where it is desirable for economy of space to have as many entries as possible on one card. In the latter case a convenient size is that of the ordinary library card, which can be ruled to hold twenty entries. The following is a form of such a card:

Albolabris (Say).	*Polygyra*
No. *1. Ann Arbor, Mich.*	No.
No.	No.
No.	No.
No.	No.
No.	No.
No.	No.
No.	No.
No.	No.
No.	No.
No.	No.

The name of the species is written on the top, and the number of each entry of that species and the locality is entered below. Such a card as this enables the collector to see at a glance not only whether any given species is represented in his collection, but also from what localities, and saves a large amount of time which would otherwise be spent in turning over the leaves of a serial catalogue.

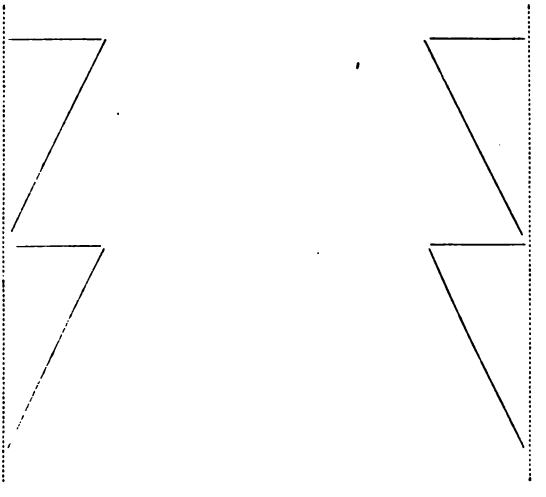
The cards can be kept in drawers or boxes of proper size and can be arranged alphabetically under the different genera and families. Guide cards slightly higher than the ordinary card, indicating the genera, can be inserted in their proper places.

In collections intended for public exhibition, it is usually necessary to have the specimens mounted on cards or blocks. But in private collections such an arrangement is a mistake. Not only on account of the greater room required for the collection, but particularly because it prevents the handling of the specimens for purposes of study.

Specimens under an inch in diameter are most conveniently kept in glass vials. These can be obtained from any wholesale druggist. They should be without a neck and of standard sizes. The length will depend upon the standard size of the tray adopted. For my own collection I use four sizes, $\frac{1}{4}$, $\frac{1}{2}$, $\frac{5}{8}$, and $\frac{7}{8}$ inches in diameter. As these vials are rather fragile, the pressure of the cork is apt to break them. The cork should therefore be softened by rolling or crushing. A pair of plumber's burner-plyers is useful for this purpose. The serial number should be put on the cork or on a small piece of paper inside. Specimens too large for the vials should have

the number on the shell in ink. Then, if a drawer happens to be overturned, the specimens can be sorted out again without difficulty.

When numbered, the vials and specimens should be placed in trays. For these a standard size should be adopted, so that they will conveniently fit into the drawers of the cabinet. In the National Museum at Washington, the unit is 1 x 2 inches, and the larger sizes are all multiples of that unit. In the Academy of Natural Sciences at Philadelphia the unit is 1 x 3 inches. In either case a convenient intermediate size is 1½ x 2 or 3, as the case may be. There is one advantage in the use of the larger unit where space is a serious question. For the small species the vials may be used only 1¼ inches in length, and two vials can be put into one tray, thus doubling the capacity of the drawer. The trays should be of the same depth. One-half inch is sufficient for most of the univalve species. For the larger species and the *Unionidæ*, requiring trays of good size, ¾ inch is better. These trays can be had of any paper box manufacturer, or can be easily cut out of cardboard by the collector, the corners being fastened together by strips of gummed paper. The character of the cases for a collection is determined by the means and inclination of the collector. Any case of shallow drawers will do. If, however, cases are to be made, they should be made of a standard size with interchangeable drawers. The standard drawer should be one inch in depth on the outside. The length and width may be of any size, provided they are always the same; 19 x 19 inches inside measurement is a convenient size for a case with two rows of drawers. Other drawers may be 2 inches or 3 inches in depth, but comparatively few of the latter size will be required. The cases may be of any height desired, according to the number of drawers needed. The method of hanging the drawers is as follows: On the inside of the cases are fastened a series of horizontal cleats one inch in depth and ⅜ in width at the broad end, extending from the top to the bottom. The following diagram will show the arrangement:



In the one-inch drawers the entire outer edge is beveled to fit the angle of the cleat, and the drawer runs on the projecting edge. In the other drawers a projecting rail is set into the side one inch from the top of the drawer,

which serves the same purpose. In this way the drawers fit close to each other and no space is lost.

The doors of the case may be of glass or paneled with wood. A thin strip of rubber set just inside the jamb, so that the door will press tightly against it when closed, serves as an efficient dust protector. It is a great nuisance, as well as a constant source of expense, to attempt to have a glass cover for each individual drawer. Cases made as above are practically dust proof.

Each tray should have a neat label giving the serial number, the name and the locality of the specimens it contains. A box, bottom-side up, can be used for separating the genera and species in each drawer. Small labels of convenient size for designating them can be had, already gummed, at any bookseller's.

PACKING SPECIMENS.

Small specimens should not be mixed with large ones, as they are apt to get lost; nor should fragile shells be put in with stronger ones, as they are likely to be broken. The minute specimens can be put into gelatine capsules, small vials, quills or paper tubes made by rolling writing paper around a lead pencil, gumming down the edge and stopping the ends with cotton. Don't mix shells from different localities. Write the locality on a label and wrap it up with each vial or package. Use plenty of cotton in packing fragile shells. Pill boxes and match boxes are convenient for packing purposes. Wrap up *each* vial or box separately, then if a smash does occur there is a fair chance of saving some of the specimens and no danger of mixing the contents of different packages. Don't send paper boxes by mail. It is simply tempting Providence. Pack in a wooden box.

IV.

METHODS OF KILLING AND DISSECTION.

"Specimens of *Polygyra* and *Limax* may be easily kept in captivity by placing them in a box in which there are about four (4) inches of earth covered with dead leaves. The earth must be kept moist. The box must be kept covered with mosquito netting or tarlatan. The mosquito netting will be sufficient for adult individuals, but the young *Limax* would escape easily through its meshes."

"Two pairs of fine scissors will be necessary, one pair with straight points, the other with curved points; one or more fine scalpels, and two pairs of fine forceps, one straight and the other curved. A pair of stronger forceps and a pair of fine pliers will be needed to remove the shell of *Polygyra*. Dissecting needles are also necessary. These can be made by forcing the heads of fine needles, by means of a pair of pliers, into the end of a round stick of smaller diameter. The point of one of these needles should be bent so as to form a hook, first heating the end of the needle to a white heat."

"I have tried all of the various methods recommended for killing *Polygyra* and *Limax*, and find only one that is uniformly successful, and that is drowning. In using hot water and various chemicals, in nearly every case the animal is more or less contracted, and thus rendered useless for the purpose of a successful dissection. In drowning the animal I have used a fruit-preserving jar, as being more convenient than a wide-mouthed bottle. This jar should be completely filled with water, so that, when the cover is fastened on, there will be no air space left. The animals being placed in the

water and the cover screwed on, the jar should be left undisturbed for 48 hours; it requiring about that length of time to drown the animals. Remaining undisturbed, they will die fully extended; but, if the jar is disturbed in the mean time, more or less contraction will take place. The animal when dead should be thoroughly washed to free it from all adhering mucus, and placed in alcohol diluted with about two-thirds the amount of water, additional alcohol being added from day to day till the mixture consists of about 75% of alcohol. The animals should then be removed and placed in undiluted alcohol, the action of the fluid on the integument prevents the proper preservation of the internal organs."

"To remove the shell, preparatory to dissecting the animal, break the peristome with a pair of pliers. The remainder of the shell can be removed with a pair of forceps, carefully breaking off a small piece of shell at a time till it is removed to the apex. The columella can be removed by holding the lower part between the thumb and forefinger of the left hand, and turning the animal with the right. As the columella is like a screw, the animal readily becomes detached by this movement."

"In dissecting the animal, a circular china dish about four inches in diameter and two in depth will be necessary; also a piece of sheet cork as large as will lie at the bottom of the dish, fastened to a thin sheet of lead with either string or rubber bands. It is best to have the lead of the same size as the cork. This leaded cork is to be placed in the bottom of the dish, and the dish filled with alcohol. If the animal has once been placed in alcohol, all dissections should be made in alcohol, but freshly killed specimens may be dissected in water, and many of the organs at this time present a much more natural appearance than when acted on by alcohol. Place the animal on the cork and fasten it down with small pins, or better yet, with very fine, short needles, inserted through the margin of the foot. Then with the fine pair of scissors, commencing at the head, cut through the integument along the center of the back, taking care not to injure any of the organs below. The integument is now to be removed from the dorsal part, turned back and fastened to the cork, removing the needles from the margin of the foot and putting them through the edges of the integument. All the organs of the anterior part of the snail are thus brought into view, and farther dissection of the organs can be intelligently made."

"In the case of the *Limax* nearly all the organs will be brought into view by turning back the integument; but great care must be taken in this genus in cutting through the integument not to injure the pulmonary chamber, as it is situated very near the surface. Also every precaution should be taken that the points of the scissors shall not go below the integument, or the intestine and upper surface of the stomach will be mutilated, and a successful dissection rendered impossible." *

V.

PREPARATION OF THE JAW AND RADULA.

"On opening the head (of the snail) from above, one readily notices at the extreme anterior part, close against the outer integument, a prominent, oval body. This is called the buccal mass. It is easily cut away from the animal, and will be found to contain both jaw and lingual mem-

* Simpson, Bull. N. Y. State Museum, VIII., pp. 241–3 (1901).

brane. These can be removed by fine scissors or knives from the buccal mass in the larger species, but in the smaller species, the method usually employed, is putting the whole buccal mass in a watch crystal, full of a strong solution of caustic potash. Allowing it to remain for several hours, the potash will destroy all of the buccal mass, and leave the jaw and lingual membrane perfectly clean and ready for examination. They must be well rinsed in clean water, in another watch crystal, before examination. Another more expeditious process, is to place the whole buccal mass in a test-tube with the solution of potash, and boil it for a few seconds over a spirit lamp. Pouring the contents of the tube into a watch crystal, the lingual membrane attached to the jaw will be readily seen by a pocket lens. If the species be small, as *Pyramidula striatella*, for instance, its whole body may be thrown into the solution. Still more minute species, as *Zonitoides milium*, for instance, may be treated in this way; crush the whole shell between two glass slides; wash the particles of broken shell in a few drops of water, still keeping the body of the animal on the slide; when clean, drop on it the caustic potash and boil it by holding the slide itself over the spirit lamp."

"For the purpose of examination, the jaw and lingual membrane may be simply mounted in water and covered with thin glass. One must be sure to spread out the lingual membrane, not have its upper side down, and it is well to cut it transversely in several places, as the teeth are beautifully shown and often stand detached on the edges of the cut.

"For preservation for future study, the glycerine preparations sold by the opticians will be found useful, though they have the great disadvantages of deliquescing in warm weather." *

The radula may also be mounted in Canada balsam. In this case they should be stained with carmine or chromic acid, as otherwise the specimen will in time become transparent.

VI.

CLASSIFICATION.

ORDER *PULMONATA*

Animal naked or covered with shell, inoperculate, terrestrial, fluviatile or marine, breathing the air by means of a lung with vascular walls and a contractile orifice. Both sexes are united in each individual, but the genital orifices are either contiguous and opening into a common duct, or separated. Jaw single or composed of three pieces; never of two symmetrical pieces. Radula with very numerous teeth in each row.

Shell of variable shape, *holostomus*.

The *Pulmonata* are divided into two sub-orders according to the position of the eyes and the character of the tentacles, viz.:

I. Eyes placed at the extremity of retractile tentacles..*Stylommatophora*.

II. Eyes placed on the base of contractile tentacles ....*Basommatophora*.

The *Stylommatophora* are as a rule terrestrial in their habits, while the *Basommatophora* are amphibious or aquatic.

The *Stylommatophora* are again divided according to the position of the genital orifices.

* W. G. Binney, Man. Am. Land Shells, p. 44.
For full instructions in regard to the preparation of the radulæ of the minute species, see Beecher, Journal N. Y. Microscopical Society, 1888, p. 7.

I. Genital orifices contiguous or united.....*Monotremata.*
II. Genital orifices separated.....*Ditremata.*

The *Ditremata* are not represented in the fauna of Michigan.

The *Monotremata* are divided into two groups, based mainly on the structure of the lung. Only one of them, the *Vasopulmonata*, is represented in the fauna of the state.

The *Vasopulmonata* are again subdivided according to modifications of the pallial region, and particularly with reference to the position of the ureter, viz.:

I. Kidney lying parallel to heart and gut; the ureter passing direct from the kidney to the anterior margin of the lung.....*Orthurethra.*
II. Kidney forming the posterior wall of the lung, lying transverse to heart and gut, its apex against the latter; ureter following the last fold of the gut forward to the mantle edge.....*Heterurethra.*
III. Kidney parallel to the gut, its apex anterior; ureter abruptly deflected from the apex, passing to the posterior end of the lung cavity; thence an open groove or closed tube continues across to the last fold of the gut, which it follows forward to the mantle edge.....*Sigmurethra.*

The *Sigmurethra* are divided into super-families, based upon characters of the foot, lung, central nervous system, radula, etc., as follows:

I. Margin of the foot defined by grooves, etc.....*Aulacopoda.*
II. No pedal grooves.
A. None of the teeth of the aculeate or thorn-like type; jaw present, distinct.....*Holopoda.*
B. All of the teeth aculeate, thorn-shaped; jaw often obsolete.
a. Cerebral ganglia concentrated, in close contact.....*Agnathomorpha.*
b. Cerebral ganglia separated, a rather long commissure connecting them.....*Agnatha.*

The *Agnatha* are not represented in Michigan.

The *Heterurethra* is composed of the single superfamily, *Elasmognatha*, characterized by the jaw being furnished with an accessory, quadrate piece, which is lacking in both the *Sigmurethra* and *Orthurethra*.

The subdivisions of the *Orthurethra*, if any, have not, as yet, been determined.

The *Holopoda*, *Agnathomorpha*, *Aulacopoda*, *Elasmognatha* and *Orthurethra* represented in the fauna of Michigan, are divided into the families shown on the following table:

CLASSIFICATION OF THE *VASOPULMONATA* OF MICHIGAN.*

Vasopulmonata	*Sigmurethra*	*Holopoda*	*Helicidæ.*
		Agnathomorpha.	*Circinariidæ.*
		Aulacopoda	*Zonitidæ.*
			Limacidæ.
			Endodontidæ.
			Philomycidæ.
	Heterurethra	*Elasmognatha*	*Succiniidæ.*
	Orthurethra		*Pupillidæ.*
			Valloniidæ.
			Cochlicopidæ.

The *Basommatophora*, according to Fischer (Man. de Con. 446) are divided into three suborders: *Gehydrophila*, *Hygrophila* and *Thalassophila*.

* Adapted from Pilsbry, Proc. A. N. S. P., 1900, 564.

Of these, only the first are terrestrial in their habits and are represented in Michigan by a single family, the *Auriculidæ*, and that only by one genus, *Carychium*.

VII.

MEASUREMENT AND DESCRIPTIVE TERMS.

The length or height of a shell is the distance from the apex to the basal edge of the lip, measured along a line drawn through the axis.

The greater diameter is the greatest width, including the lip, measured on a line drawn at right angles to the axis.

The lesser diameter is measured on the same plane, but on a line at right angles to the greater diameter.

Shells are dextral or sinistral, accordingly as the aperture is on the right or left of the axis, when held, apex uppermost, with the aperture facing the observer.

The remainder of the terms in common use are sufficiently indicated on the following diagram:

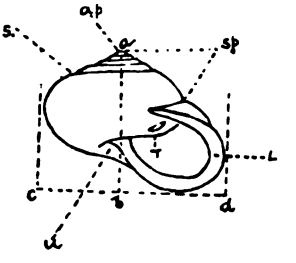


Fig. 1.

a to b.	height.	c to d.	greater diameter.
ap.	apex.	u.	umbilicus.
s.	suture.	l.	lip.
sp.	spire.	t.	parietal tooth.

In using the keys, it is to be borne in mind that they are framed on typical, mature specimens. Varietal and abnormal, or aberrant forms and immature specimens must be determined by careful study of the descriptions and comparisons with normal, adult examples. The name in parentheses after the name under a figure indicates the author from whom the figure is copied, not the authority for the specific name. Figures not so designated are original. All figures of entire shells are life-size unless otherwise indicated.

CATALOGUE.

Order **PULMONTA.**

Sub-order STYLOMMATOPHORA.

MONOTREMATA.

VASOPULMONATA.

I. SIGMURETHRA.

Superfamily HOLOPODA.

Family **HELICIDÆ.**

Foot edges without pedal grooves; sole undivided; marginal teeth with wide, short, squarish basal-plates and one or several cusps, the outer cusp never elevated on middle cusp. Shell usually with an expanded or reflexed lip.

Sub-family **POLYGYRINÆ** Pilsbry.

Genitalia simple; *vas deferens* inserted directly on the well developed long penis, which has no epiphallus or flagellum; no dart sack or mucus glands; no diverticulum on spermatheca duct; eggs small and numerous. Jaw solid, ribbed or smooth; marginal teeth with more than one cusp. Shell with lip thickened within, expanded or reflexed; the embryonic whorls not distinctly differentiated.

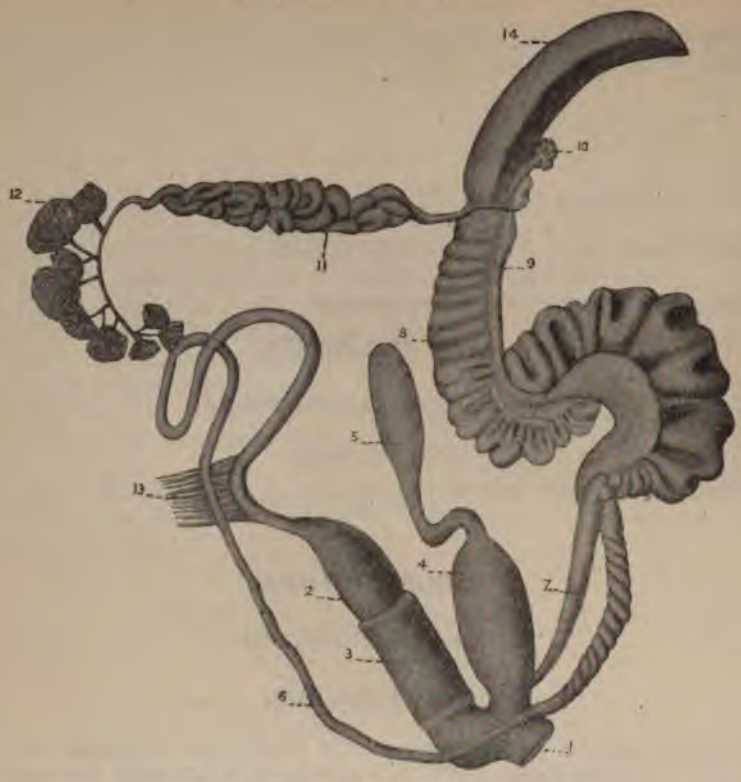


Fig. 2. Genitalia of *P. albolabris* (Simpson).

1. Atrium.	6. Vas deferens.	11. Hermaphroditic duct.
2. Penis.	7. Free oviduct.	12. Hermaphroditic gland.
3. Prepuce.	8. Uterus.	13. Penis retractor.
4. Vagina.	9. Spermatic duct.	14. Albumen gland.
5. Spermatheca.	10. Talon.	

Genus **POLYGYRA** Say.

Shell helicoid, varying from globose or depressed-globose to lens-shaped or planorboid; the periphery carinated or rounded; umbilicus either open or closed. Surface striated or hirsute; corneous, yellow or brown, generally unicolored, but sometimes with many bands, the most constant being supraperipheral, the others when present being wholly indefinite in number and position. Lip well reflexed; aperture typically obstructed by three teeth; one parietal, two upon the lip; but any or all teeth often wanting.

Fig. 3. Animal of *P. albolabris*. (Binney.)

Animal heliciform, the mantle sub-central, foot rather long and narrow. No pedal grooves. Surface rather coarsely and irregularly granulated, the granulations finer posteriorly; back with a pair of indistinct grooves extending from mantle to facial area; sides of foot, and sides of top of tail without any distinct, oblique or longitudinal lines, irregularly granulated; tail rounded above, obtuse behind.

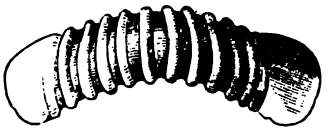


Fig. 4. Jaw of *P. albolabris*. (Binney.)

Jaw arcuate, solid and strong, sculptured with seven to twenty convex ribs; cutting edge without median projection, but denticulated by the ribs.

Radula generally with tricuspid centrals and bicuspid laterals and marginals, the side cusps well developed; in some species, however, there are no side cusps or cutting points whatever on any of the teeth.

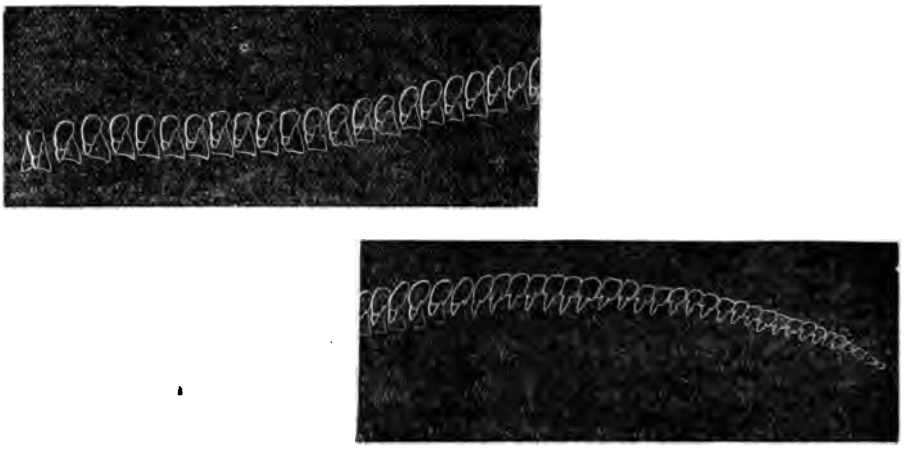


Fig. 5. Dentition of *P. albolabris*. (Binney.)

KEY TO SECTIONS OF *POLYGYRA*.

I. Aperture lunate, oblique, outer lip broadly expanded.....*Triodopsis*.
II. Aperture narrow, basal, outer lip reflexed, not expanded beyond contour of body whorl.....*Stenotrema*.

Section **TRIODOPSIS** Rafinesque.

Shell varying from depressed to globose conoidal, umbilicate or imperforate; surface generally striated; whorls 5-6, the last wider, more or less deflexed in front; aperture lunate, typically obstructed by three teeth, two on the lip, on the parital wall, but any or all of the teeth often absent.

KEY TO THE SPECIES OF *TRIODOPSIS*.

I. Aperture tridentate.
  a. Striate and umbilicate.
    b. Peristome flattened, not inflected above, labial teeth small, of uniform size.....*tridentata*.
    bb. Peristome strongly inflected above, aperture dish-shaped, upper labial tooth larger.....*fraudulenta*.
  aa. Hirsute and imperforate.
    b. Diameter exceeding 20 mill., lip broadly expanded, basal tooth long, lamellar.....*palliata*.
    bb. Diameter less than 15 mill., lip not expanded beyond contour of body whorl, basal tooth small and acute.....*inflecta*.

II. Aperture bidentate.
  a. Umbilicate.....*sayana.*
  aa. Imperforate.....*elevata.*
III. Aperture unidentate.
  a. Umbilicate.
    b. Single tooth on basal lip.....*profunda.*
    bb. Single tooth on parietal wall.....*thyroides.*
  aa. Imperforate.
    b. Body whorl wide, diameter twice the height.....*albolabris dentata.*
    bb. Body whorl ventricose, diameter less than twice the height, *exoleta.*
IV. Aperture edentate.
  a. Umbilicate.
    b. Coarsely striate, lip broadly reflected.....*thyroides.*
    bb. Finely striate, shining, lip narrower; smaller.....*clausa.*
  aa. Imperforate.
    b. Diameter exceeding 20 mm., distinctly striate.
      c. Lip heavy, broadly reflected; uncolored.....*albolabris.*
      cc. Lip thin, narrowly reflected; usually banded.....*multilineata.*
    bb. Diameter not exceeding 17 mm.
      c. Globosely depressed, polished.....*mitchelliana.*
      cc. Convexly elevated, striate.....*pennsylvanica.*

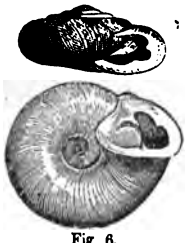


Fig. 6.
P. tridentata. (Binney.)

POLYGYRA TRIDENTATA (Say).

Shell umbilicated, depressed; light horn or chestnut colored spire very low; whorls 5½, rather convex, the last scarcely deflected in front; aperture trilobate; peristome white, flatly reflected, thickened within, with two acute teeth on its inner margin, a strong oblique tooth on the parietal wall. Alt. 8, greater diam. 16, lesser 14 mm.

Helix tridentata, Say, Nich. Encycl., pt. II, fig. 1 (1817).
Triodopsis ————, W. G. Binney, Man. Am. Land Shells, 291, fig. 312, (1885).
Helix ————, Sager, Doc. H. Rep. Mich., 1839, 420, separate, 14.
—— ————, Miles, Rep. Geol. Surv. Mich., 236, (1861).
Triodopsis ————, Currier, Shell-bearing Moll. Mich., 6, (1868).
———— ————, DeCamp, Shell-bearing Moll. Mich., 7, (1881).
Polygyra ————, Walker, Rev. Moll. Fauna, Mich., 17, (1894).

Not a very abundant species. Saginaw-Grand valley and southeastern counties north to Lapeer county. Not reported from the southwestern part of the state, nor north of the Saginaw-Grand valley

Fig. 7.
fraudulenta.
(Binney)

POLYGYRA FRAUDULENTA (Pilsbry).

Shell umbilicated, depressed, globose, ribbed striate; reddish horn colored; spire convex; whorls 6, rather convex, the last deflected anteriorly, constricted behind the lip; aperture trilobate, with a large oblique tooth on the parietal wall; peristome reflected, thickened within, concave above, white, with two teeth, the upper one decidedly inflected, the other subbasal, acute. Alt. 7½, greater diam. 13, lesser 11 mm.

Polygyra tridentata fraudulenta Pilsbry, Proc. A. N. S. P. 1894, 20, pl. I., fig. 6.
Triodopsis fallax, W. G. Binney, Man. Am. Land Shells, 292, fig. 314, (1885).
Helix ———, Sager, Doc. H. Rep. Mich., 1839, 420, separate 14.
—— ———, Miles, Rep. Geol. Surv. Mich., 235, (1861).
Triodopsis ———, Currier, Shell-bearing Moll. Mich., 6, (1868).
———— ———, DeCamp, Shell-bearing Moll. Mich., 7. (1881).
Polygyra fraudulenta, Walker, Rev. Moll. Fauna, Mich., 17, (1894).

More abundant than the preceding species. Distribution the same.

This species is frequently confounded with *P. tridentata*, but is very distinct and can be easily separated by its basin-shaped aperture and the larger size of the superior labial tooth.

POLYGYRA INFLECTA (Say).

Fig. 8. *P. inflecta.* (Binney)

Shell imperforate, depressed, epidermis brownish horn-color; very finely hirsute; whorls with very minute transverse striæ; suture not much impressed; aperture tri-lobed, very much contracted behind the lip; peristome white, narrow, reflected, not projecting beyond the contour of the body whorl; on the inner margin of the peristome are two acute teeth, with the points directed inwards, one near the base, the other midway between that and the junction of the peristome and the body whorl, with a circular sinus between them; parietal wall with a long arcuated, white tooth. Alt. 6¾, greater diam. 12, lesser 11 mm.

Helix inflecta, Say, Jour. A. N. S. P. II., 153, (1821).
Triodopsis ———, W. G. Binney, Man. Am. Land Shells, 289, fig. 310, (1885).
Helix ———, Sager, Doc. H. Rep. Mich. 1839, 420, separate, 14.
—— ———, Miles, Rep. Geol. Surv. Mich., 235, (1861).
Isognomostoma ———, Currier, Shell-bearing Moll. Mich., 6, (1868).
———— ———, DeCamp, Shell-bearing Moll. Mich., 7, (1881).
Polygyra ———, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Quite rare. Kent, Washtenaw, Wayne and Monroe counties. Distinguished from the other tridentate species by its small size and imperforate base.

POLYGYRA PROFUNDA (Say).

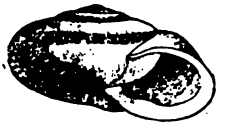


Fig. 9. *Polygyra profunda.* (Binney.)

Shell broadly umbilicated, orbicularly depressed; yellowish horn-colored, with reddish brown revolving lines and bands; whorls 5, convex, obliquely striated; suture distinct; aperture almost circular, its extremities converging, flattened towards the plane of the base; peristome white, thickened, reflected, with an obtuse tooth on the basal edge; umbilicus rather large and profound; base convex. Alt. 1'4, greater diam. 29, lesser 27 mm.

Helix profunda, Say, Jour. A. N. S. P. II, 160, (1821).
Mesodon profundus, W. G. Binney, Man. Am. Land Shells, 318, fig. 342, (1885).

Helix profunda, Sager, Doc. H. Rep. Mich., 1839, 420; separate, 14.
——— ———, Miles, Rep. Geol. Surv. Mich., 236, (1861).
Ulostoma ———, Currier, Shell-bearing Moll. Mich., 5, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 6, (1881).
Polygyra ———, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Var. **ALBA** (Walker).

White or pale yellowish horn-color, without bands.

Polygyra profunda alba, Walker, Terr. Moll. Mich., 12, (1899).

Southern part of the state. Not yet reported north of Muskegon county on the west and Macomb county on the east in the lower peninsula.* The variety occurs occasionally, associated with the typical form, in Washtenaw and Monroe counties. The other extreme in coloration, in which the bands coalesce and cover the entire surface (var. *unicolor*) has not yet been noticed in this state.

POLYGYRA SAYANA Pilsbry.

Fig. 10. *P. sayana.* (Binney.)

Shell umbilicated, orbicularly depressed, thin; light russet, shining; whorls 5-6, finely and obliquely striate; suture impressed; aperture sub-circular; peristome white, narrow, reflected, with a slightly projecting tooth on the inner edge of the basal portion near the umbilicus; parietal wall with a sub-prominent, white tooth; umbilicus moderate, deep base; rounded.

Alt. 14, greater diam. 23, lesser 19 mm.

Polygyra sayana Pilsbry, Proc. A. N. S. P. 1906, 127.
Mesodon sayii, W. G. Binney, Man. Am. Land Shells, 319, fig. 343, (1885).
Helix ——, Miles, Rep. Geol. Surv. Mich., 236, (1861).
Ulostoma ——, Currier, Shell-bearing Moll. Mich., 5, (1868).
——— ——, DeCamp, Shell-bearing Moll. Mich., 6, (1881).
Polygyra ——, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Rare and restricted to the northern part of the state, Reported from Charlevoix, Emmet, Presque Isle, Huron and Tuscola counties. Not reported from the upper peninsula.

POLYGYRA ALBOLABRIS (Say).

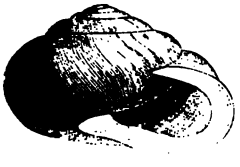


Fig. 11. *P. albolabris.* (Binney.)

Shell imperforate, convex; unicolored, yellowish-brown, russet, or light chestnut color; whorls 5-6, finely and obliquely striate and decussated with very minute, but distinct, wavy, impressed, revolving lines, which are most apparent on the back of the reflected peristome, suture well impressed; peristome white, flattened, abruptly and very widely reflected. Alt. 15¼-24¼, diam. 24¾-34¼ mm.

Helix albolabris, Say, Nich. Encycl., pl. I., fig. 1, (1817).
Mesodon ———, W. G. Binney, Man. Am. Land Shells, 298, fig. 319, (1885).
Helix ———, Sager, Doc. H., Rep, Mich., 1839, 420; separate, 14.
——— ———, Miles, Rep. Geol. Surv. Mich., 235, (1681).

* In the upper peninsula it has been found in Iron and Dickinson counties.

Mesodon albolabris, Currier, Shell-bearing Moll. Mich., 5, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 6, (1881).
Polygyra ———, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Var. **DENTATA** Tryon.

Fig. 12. Var. *dentata*. (Binney.)

Parietal wall with a slight denticle.

Mesodon albolabris dentata, Tryon, Am. Jour. Con. III., 39, pl. vii., fig. 6, (1867).
——— ——— ———, Currier, Shell-bearing Moll. Mich., 5, (1868).
——— ——— ———, DeCamp, Shell-bearing Moll. Mich., 6, (1881).
Polygyra ——— ———, Walker, Rev. Moll. Fauna Mich., 16, (1894).

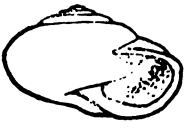


Fig. 13. Var. *maritima*. (Pilsbry.)

Var. **MARITIMA** (Pilsbry.)

Shell smaller, surface very distinctly and beautifully decussated by spiral and oblique lines. Base notably swollen near the umbilicus, back of the lip.

Alt. 12-17, diam. 18¾-24½ mm.

Helix albolabris maritima, Pilsbry, Proc. A. N. S. P., 1890, 283, fig.
Polygyra ——— ———, Walker, Rev. Moll. Fauna Mich., 16, (1894).
——— ——— *traversensis*, "Leach," Pilsbry, Man. Con. IX, 76, (1894).
——— ——— *minor*, Sterki, L. & F. W. Moll. N. Phila, 4, (1894).
——— ——— ———, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Abundant over the entire state, and exhibits great variation in size, color and thickness of the shell. Deeply colored examples when fresh, frequently have the lip tinged with light purple, which, however, fades out gradually, especially when exposed to the light. The dentate form occurs not infrequently associated with the type. It is, perhaps, questionable whether the true var. *maritima* occurs in this state. The shells from Traverse City, called var. *traversensis* by Leach, but never formally described, are very similar, but not quite typical, lacking the swollen base characteristic of the New Jersey form. They seem to be intermediate between the true *maritima* and the form described by Sterki as var. *minor*. The same form has been found at Grand Rapids, and occurs in many localities in the sandy districts in the western and northern parts of the state. It is an interesting coincidence, if nothing more, that this form first discovered in the sandy regions of New Jersey, should reappear under similar environmental conditions in Michigan, and be accompanied by a fluviatile form (*Lymnæa galbana* Say), which, until found here, was considered extinct and peculiar to the recent deposits in New Jersey.

Taking all the material now accessible into consideration, it does not seem feasible to separate the several forms known as *maritima*, *traversensis* and *minor* into distinct varieties. As a whole they seem to be a well marked depauperate race, the result of unfavorable conditions of environment and characteristic of the sandy regions of the northern and western counties. But they vary in size and contour quite as much as the typical form and grade insensibly into each other and into it. At present therefore, it would

seem best to consider them simply as phases of one variety and to unite them under the name having priority.

P. albolabris rufa DeKay, cited by DeCamp, is simply a more deeply colored form and is not entitled to varietal distinction.

POLYGYRA ZALETA (Binney).

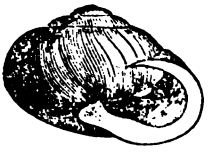


Fig. 14. *P. zaleta.* (Binney.)

Shell imperforate, convex, somewhat ventricose; uniform yellowish horn or russet color; whorls 5-6, finely and obliquely striate; body whorl large and ventricose; suture well marked; aperture rounded; peristome thickened, white, reflected; parietal wall with a prominent, white, oblique tooth.

Alt. 17, greater diam. 28, lesser 23 mm.

Helix zaleta, Binney, Bost. Jour. Nat. Hist. I., 492, pl. xx, (1837).
Mesodon exoletus, W. G. Binney, Man. Am. Land Shells, 39, fig. 331, (1885).
Helix zaleta, Sager Doc. H. Rep. Mich., 1839, 420, separate, 14.
——— *exoleta*, Miles, Rep. Geol. Surv. Mich., 235, (1861).
Mesodon ———, Currier, Shell-bearing Moll. Mich., 5, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 6, (1881).
Polygyra ———, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Probably extends over the entire southern part of the state, although not yet reported west of Saginaw, Ingham and Branch counties. The only records north of the Saginaw-Grand valley are Osceola and Mackinac counties. This species is frequently mistaken for the dentate form of *P. albolabris* or *vice-versa*, and, indeed, in some cases it is not easy to tell from the shell alone, where a given specimen belongs. In such cases a dissection of the animal is necessary, as there are very distinct differences in the details of the genitalia. Usually, however, the two forms can be separated without difficulty, *zaleta* being much more ventricose and having a rounder aperture than *albolabris*, which is more depressed, wider in proportion to its heighth, and with the aperture wider and more flattened in the direction of the plane of the base. Usually known as *P. exoleta* Binney, but *zaleta* has priority

POLYGYRA MULTILINEATA (Say).

Fig. 15. *P. multilineata.* (Binney)

Shell imperforate, depressed, sub-globose; spire convex; rather thin; yellowish brown, or russet color, with numerous reddish, revolving bands; whorls 5-6, convex, closely and obliquely striate, the last ventricose; suture distinctly marked; aperture lunate; peristome white, reflected, rather thin.

Alt. 14, greater diam. 23, lesser 20 mm.

Helix multilineata, Say, Jour. A. N. S. P., II., 150, (1821).
Mesodon multilineatus, W. G. Binney, Man. Am. Land Shells, 302, fig. 323, (1885).
Helix multilineata, Sager, Doc. H. Rep. Mich., 1839, 420, separate, 14.
——— ———, Miles, Rep. Geol. Surv. Mich., 236, (1861).
Mesodon ———, Currier, Shell-bearing Moll. Mich., 5, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 6, (1881).
Polygyra ———, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Var. **ALBA** Witter.

Helix *multilineata alba*, Witter, Quar Jour. Con., I., 384, (1878).
Mesodon ———— ——, Currier, Shell-bearing Moll. Mich., 5, (1868).
——— ———— ——, DeCamp, Shell-bearing Moll. Mich., 6, (1881).
Polygyra ———— ——, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Unicolored, pale horn-color without bands.

Var. **RUBRA** Witter.

Helix *multilineata rubra*, Witter, Quar. Jour. Con., I., 384, (1878).
Mesodon ———— *unicolor*, Currier, Shell-bearing Moll. Mich., 5, (1868).
——— ———— ———, DeCamp, Shell-bearing Moll. Mich., 6, (1881).
Polygyra ———— ———, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Unicolored, deep reddish brown or chestnut.

Abundant south of the Saginaw-Grand valley. North of that it has been reported only from Benzie and Osceola counties. It also occurs in Menominee county in the upper peninsula. The varieties occur occasionally associated with the typical form, although var. *rubra* has not yet been reported from the eastern part of the state.

A peculiar color-form, deep brown or chestnut color with a yellowish band of variable width and position between the periphery and umbilical depression has been found in Kent county.

POLYGYRA PALLIATA (Say).

Fig. 16. *P. palliata.* (Binney.)

Shell imperforate, thin, depressed; light to dark brown or chestnut color, and rough with minute, acute, projections and stiff hairs; whorls 5, flattened above and rounded below, with numerous fine oblique striæ; aperture trilobate, much contracted by the peristome and teeth; peristome white, widely reflected, with two projecting teeth on the inner margin, the upper one acute and prominent, the basal tooth long, lamellar; parietal wall with a very prominent, white, curved tooth.

Alt. 10, greater diam. 21, lesser 18 mm.

Helix *palliata*, Say, Jour. A. N. S. P., II., 152, (1821).
Triodopsis ———, W. G. Binney, Man. Am. Land Shells, 284, fig. 303, (1885).
Helix ———, Sager, Doc. H. Rep. Mich. 1839, 420, separate, 14.
——— ———, Miles, Rep. Geol. Surv. Mich., 236, (1861).
Xolotrema ———, Currier, Shell-bearing Moll. Mich., 5, (1868).
———— ———, DeCamp, Shell-bearing Moll. Mich., 6, (1881).
Polygyra ———, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Saginaw-Grand valley and southeastern part of the state. It will probably be found to have a general distribution through the entire southern portion, although it has not been reported from any of the southwestern counties.

Currier lists a var. *alba*, but gives no description. It is not represented in his collection now in the Kent Scientific Museum at Grand Rapids. DeCamp also quotes it as being in his collection, but it was not there when the collection came into my possession. It has not been found by any Michigan collectors.

POLYGYRA ELEVATA (Say).

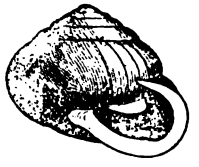


Fig. 17. *P. elevata.* (Binney.)

Shell imperforate, very convex, elevated, almost conical; yellowish horn-color; whorls 7, rounded, finely; obliquely striate, the last ventricose; suture distinct, aperture contracted by the peristome, somewhat triangular; peristome white, thickened, reflected, its basal portion with an obsolete lamellar denticle; parietal wall with a large, white, obliquely curved tooth.

Alt. 17, greater diam. 25, lesser 20 mm.

Helix elevata, Say, Jour. A. N. S. P., II., 154, (1821).
Mesodon elevatus, W. G. Binney, Man. Am. Land Shells, 306, fig. 328, (1885).
Helix elevata, Sager, Doc. H. Rep. Mich., 1839, 420, separate, 14.
——— ———, Miles, Rep. Geol. Surv. Mich., 235, (1861).
Xolotrema ———, Currier, Shell-bearing Moll. Mich., 5, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 6, (1881).
Polygyra ———, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Very rare. Niles and Grand Rapids are the only authentic localities. It has been reported from Osceola County, and as fossil in recent deposits near Ann Arbor.

POLYGYRA PENNSYLVANICA (Green).

Fig 18. *P. pennsylvanica.* (Binney.)

Shell imperforate, globosely elevated, yellowish horn-colored; whorls 6, closely and obliquely striate; suture impressed; aperture subtriangular; lip narrow, white, roundly reflected with a slight thickening at the base; umbilical region indented.

Alt. 11, diam. 18 mm.

Helix pennsylvanica, Green, Cont. Macl. Lyc. I. 8, (1827).
Mesodon pennsylvanicus, W. G. Binney, Man. Am. Land Shells, 304, fig. 324, (1885).

Monroe county and Bois Blanc Island, Detroit river.

The occurrence of this species in Michigan was until the present year (1906) considered extremely doubtful. It has, however, been recently collected by Sister M. Catherine near Monroe. It is easily distinguished from allied species by its striate surface, imperforate base and edentulous aperture.

POLYGYRA THYROIDES (Say).

Fig. 19. *P. thyroides.* (Binney.)

Shell narrowly umbilicate, depressed, globose; uniform light horn or russet color; whorls 5, finely and obliquely striate; spire more or less elevated; suture well impressed; aperture oblique, lunate; parietal wall with a prominent white tooth, which is occasionally obsolete; peristome white, thickened; widely reflected; its exterior yellowish; umbilicus partially covered by the reflected peristome.

Alt. 13, greater diam. 22, lesser 19½ mm.

Helix thyroidus, Say, Jour. A. N. S. P. I., 123, (1817).
Mesodon thyroides, W. G. Binney, Man. Am. Land Shells, 313, fig. 235, (1885).

Helix *thyroidus*, Sager, Doc. H. Rep. Mich., 1839, 420, separate, 14.
——— *thyroides*, Miles, Rep. Geol. Surv. Mich., 236, (1861).
Mesodon ———, Currier, Shell-bearing Moll. Mich., 5, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 6, (1881).
Polygyra ———, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Var. **PULCHELLA** Cockerell.

Helix thyroides pulchella, Cockerell, Jour. Con., VII., 39, (1892).

Pale horn-color, tinged with vinous, especially near the aperture.

Generally distributed through the southern part of the state and on the western side ranges as far north as Chippewa county. The variety occurs not unfrequently in Kent county.

POLYGYRA CLAUSA (Say).

Fig. 20. *P. clausa.* (Binney.)

Shell sub-imperforate, conoidly semi-globose, rather solid with crowded rib-like striæ; yellowish horn-color, shining; whorls 5½, rather convex, gradually increasing, the last rounded, constricted behind the lip; umbilicus narrow, almost covered by the reflected peristome; aperture rounded; peristome narrow, white, reflected; base very convex.

Alt. 11½, greater diam. 18½, lesser 16 mm.

Helix *clausa*, Say, Jour. A. N. S. P., II., 154, (1821).
Mesodon *clausus*, W. G. Binney, Man. Am. Land Shells, 315, fig. 338, (1885).
Helix *clausa*, Sager, Doc. H., Rep. Mich., 1839, 420, separate, 14.
——— ———, Miles, Rep. Geol. Surv. Mich., 235, (1861).
Polygyra ———, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Very rare in Michigan. Until recently Grand Rapids was the only authentic locality recorded. But it has been lately collected in considerable abundance near Monroe.

POLYGYRA MITCHELLIANA (Lea).

Fig. 21. *P. mitchelliana* (Binney.)

Shell imperforate, depressed conoid-globose, thin; finely striate; yellowish horn-color, polished; spire briefly conoid; whorls 5, moderately convex, gradually increasing, the last ventricose, sub-constricted behind the lip; aperture rounded, peristome narrow, white, thickened, reflected; base very convex.

Alt. 10, greater diam. 16½, lesser 14½ mm.

Helix *mitchelliana*, Lea, Trans. A. P. S., VI., 87, pl. XXIII, fig. 71, (1839).
Mesodon *mitchellianus*, W. G. Binney, Man. Am. Land Shells, 305, fig. 326, (1885).
Polygyra *mitchelliana*, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Very rare. Armada, Macomb county, is the only reported locality. This species in general appearance is very similar to *P. clausa*, but is distinguished by being imperforate.

Section **STENOTREMA** Rafinesque.

Shell small, compact, imperforate or umbilicate; sub-globose, globosely depressed or lens-shaped, the periphery varying from rounded to acutely keeled, surface dull, smooth, generally hirsute. Whorls, 5-6 closely revolving, the last suddenly deflexed in front. Aperture basal, narrow, obstructed by an oblique blade-like parietal tooth, parallel to the reflexed basal lip, the latter often notched in the middle. Last whorl generally having in its last fourth, a short, transverse, internal partition on the axis.

KEY TO THE SPECIES OF *STENOTREMA*.

I. Lip notched ..... *hirsuta.*
II. Lip without notch.
  a. Base narrowly excavated, imperforate or narrowly umbilicate, hirsute, diameter 11 mm..... *fraterna.*
  aa. Basal excavation and umbilicus wider, smooth, depressed, diameter 9 mm..... *monodon.*

POLYGYRA HIRSUTA (Say).

Fig. 22. *P. hirsuta* (Binney.)

Shell imperforate, sub-globose; brownish or chestnut, thickly hirsute; spire convex, elevated; whorls 5, rounded; suture distinct; aperture contracted, very narrow, almost closed by an elongated, lamelliform tooth on the parietal wall, extending from the center of the base into the edge of the aperture; peristome narrow, very much depressed and reflected against the outer whorl, with a deep notch near the centre; base convex.

Alt. 4⅔, greater diam. 7½, lesser 7 mm.

Helix hirsuta, Say, Jour. A. N. S. P., I., 17, (1817).
Stenotrema hirsutum, W. G. Binney, Man. Am. Land Shells, 278, fig. 295, (1885).
Helix hirsuta, Sager, Doc. H. Rep. Mich., 1839, 420, separate, 14.
——— ———, Miles, Rep. Geol. Surv. Mich., 235, (1861).
Stenotrema ———, Currier, Shell-bearing Moll. Mich., 5, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 7, (1881).
Polygyra ———, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Common where found, but apparently local in its distribution. Macomb, Wayne, Washtenaw, and Monroe, in the southeastern part of the state, and Branch, Berrien, Kent, and Muskegon, in the western, are the only counties thus far to be credited with it. It probably has a general distribution south of the Saginaw-Grand Valley.

POLYGYRA FRATERNA (Say).

Fig. 23. *P. fraterna.* (Binney.)

Shell narrowly umbilicated or imperforate, globose, depressed, reddish horn-colored, minutely hirsute; whorls 5½, the upper ones flattened, the two last convex, the last constricted behind the peristome; aperture widely lunar, with a lamelliform tooth on the parietal wall; peristome narrow, reflected, base convex, narrowly excavated.

Alt. 6, greater diam. 11, lesser 10 mm.

Helix fraterna, Say, Long's Exped. II, 257, pl. XV., fig. 3, (1824).

Stenotrema monodon, W. G. Binney, Man. Am. Land Shells, 280, fig. 298-9, (1885).
Helix *fraterna*, Sager, Doc. H. Rep. Mich., 1839, 420, separate, 14.
—— ————, Miles, Rep. Geol. Surv. Mich., 235, (1861).
—— *monodon*, Miles, Rep. Geol. Surv. Mich., 236, (1861).
Stenotrema ————, Currier, Shell-bearing Moll. Mich., 6, (1868).
———— ————, DeCamp, Shell-bearing Moll. Mich., 7, (1881).
———— *fraterna*, DeCamp, Shell-bearing Moll. Mich., 7, (1881).
Polygyra *monodon*, Walker, Rev. Moll. Fauna Mich., 17, (1894).
———— ———— *fraterna*, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Var. **ALBIDA** Walker.

Pale greenish-white.
Polygyra monodon albida, Walker, Terr. Moll. Mich., 15, (1899).

The umbilicate form has an abundant and general distribution in all parts of the state. The imperforate variety is apparently restricted to the southern part of the state, while the var. *albida* has thus far been reported only from Charlevoix and Grand Rapids. This species has been commonly known as *P. monodon* Rackett, the imperforate form being designated as var. *fraterna* Say. But it seems that Rackett's species is that described by Ward as *P. leaii*. It follows that this form must be given Say's name. The umbilicate and imperforate forms inosculate too closely to justify varietal distinction.

POLYGYRA MONODON (Rackett).

Fig. 24. *P. monodon*

Shell umbilicate, globosely depressed, light horn-color, whorls 6, obsoletely striate, narrow, slowly and regularly increasing, convex, the last somewhat flattened below the periphery and constricted behind the peristome; suture distinctly depressed; base convex, rather widely excavated around the umbilicus; a prominent oblique white tooth on the parietal wall; peristome narrowly reflected.
Alt. 5, greater diam. 9, lesser 8 mm.
Alt. 4, greater diam. 7, lesser 6½ mm.

Helix *monodon*, Rackett, Linn. Trans. XIII., 42, pl. V., fig. 2, (1822).
Stenotrema monodon leaii, W. G. Binney, Man. Am. Land Shells, 281, fig. 297, (1885).
———— *leai*, Currier, Shell-bearing Moll. Mich., 6, (1868).
———— *leaii*, DeCamp, Shell-bearing Moll. Mich., 7, (1881).
Polygyra ——. Walker, Rev. Moll. Fauna Mich., 17, (1894).

Generally distributed south of the Saginaw-Grand valley. Alpena, the type locality, is the only reported locality further north.

This abundant little species is easily distinguished from *P. fraterna* by its smaller size, with one more whorl, larger umbilicus and wider basal excavation and lack of epidermal hairs. Its habits also are quite different as it is usually found in low damp places, such as river margins, where it is associated with the *Succineas*, *Zonitoides nitidus*, *Pomatiopsis lapidaria* and other small moisture-loving species; while *fraterna* is usually found in the dryer localities frequented by the larger helices. It has until quite recently been known as *P. leaii* (Ward). but Dr. Pilsbry has shown that this form was the type of Rackett's species.

Superfamily AGNATHOMORPHA.

Family **CIRCINARIIDÆ.**

Animal naked, with an internal shell or bearing an external, heliciform shell. Foot without pedal grooves or caudal mucus pore. Jaw ribless, with or without a median projection on the cutting margin. Radula with arcuate rows of teeth. Centrals short, rudimentary; marginals aculeate, with narrow basal plates.

Genus **CIRCINARIA** (Beck) Pilsbry.

Shell thin, widely umbilicated, depressed, striate or wrinkled; color uniform; whorls 4½-5, the last broad, depressed, moderately deflexed in front; aperture obliquely ovate; peristome somewhat thickened or expanded, the margins approximating, the basal shortly reflexed.

Fig. 25. Animal of *C. concava*. (Binney.)

Animal heliciform; mantle posterior covered with a shell; eye-peduncles long and slender; foot narrow, twice as long as diameter of shell, tail pointed, scarcely reaching behind the shell; respiratory and anal orifices on the right of the mantle under the peristome of the shell; generative orifice behind the right eye peduncle; no distinct locomotive disk or caudal mucus pore.

Fig. 26. Jaw of *C. concava*. (Binney.)

Jaw crescentic, ends sharply pointed, anterior surface striated; cutting margin smooth, with a median projection.

Radula with the rows of teeth arranged *en chevron*. Centrals very small, basal plate triangular, apex pointed forward, more or less truncated and incurved; lower lateral angles somewhat expanded, base incurved, uni or tricuspid; laterals wanting; marginals arculeate with long narrow basal plates.

Fig. 27. Dentition of *C. concava*. (Binney.)

CIRCINARIA CONCAVA (Say).

Fig. 28. *C. concava*. (Binney.)

Shell depressed, whitish or greenish-white horn-color; whorls above flattened; rounded below; finely striate, outer whorl expanding slightly towards the aperture; suture rather deeply impressed; umbilicus wide and deep; aperture rounded, somewhat flattened above; its edge frequently tinged with reddish brown; peristome slightly thickened and subreflected below.

Alt. 8, greater diam. 17, lesser 14 mm.

Helix concava, Say, Jour. A. N. S. P., II., 159, (1821).
Macrocylis ———, W. G. Binney, Man. Am. Land Shells, 199, fig. 209, (1885).

Helix *concava*, Sager, Doc. H. Rep. Mich., 1839, 420, separate, 14.
—— ———, Miles, Rep. Geol. Surv. Mich., 235, (1861).
Macrocylis ———, Currier, Shell-bearing Moll. Mich., 4, (1868).
———— ———, DeCamp, Shell-bearing Moll. Mich., 5, (1881).
Selenites *concavus*, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Generally distributed south of the Saginaw-Grand Valley. North of that it has only been reported from Lime island in the St. Mary's river.

Superfamily AULACOPODA.

KEY TO THE FAMILIES OF *AULACOPODA*.*

I. Marginal teeth with narrow, lengthened basal plates, either unicuspid and thornlike or bicuspid by elevation of outer on middle cusps.
  a. Foot-margin wide; shell more or less spiral, ovotestis imbedded in liver ..... *Zonitidæ*.
  aa. Foot-margin narrow; shell a thin internal plate, not spiral; ovotestis free from liver ..... *Limacidæ*.
II. Marginal tooth with short, wide and squarish basal plates with one or several cusps, the outer cusp never elevated on middle cusp.
  a. Shell spiral, usually wholly external ..... *Endodontidæ*.
  aa. No shell, mantle covering the whole upper surface ..... *Philomycidæ*.

Family ZONITIDÆ.

Animal entirely covered with an external, more or less shining shell, with or without caudal mucus-pore; foot-margin wide and sole frequently tripartite, defined by a pedal groove; ovotestis imbedded in liver; marginal teeth with narrow, elongated basal plates and either unicuspid and thorn-shaped by suppression of side cusps, or bicuspid by elevation of outer on middle cusps.

KEY TO GENERA OF *ZONITIDÆ*.†

I. System bearing a long dart-sack surmounted by one or more coronal glands, and usually containing a slender, curved dart.
  a. Shell with internal teeth, or a layer of callus on the floor of last whorl ..... *Gastrodonta*.
  aa. No internal teeth or callus.
    b. Surface polished or with minute spiral lines ..... *Zonitoides*.
    bb. Surface conspicuously striate or constulate ..... *Pseudohyalina*.
II. System lacking dart-sack and its accessories.
  a. No noticeable shell-lobes developed, caudal mucus-pore present.
    b. Shell small depressed and glassy; lower part of vas deferens not enlarged ..... *Vitrea*.
    bb. Shell larger, smoky; lower part of vas deferens greatly enlarged ..... *Omphalina*.
  aa. Right shell lobe developed; no caudal pore ..... *Vitrina*.

* Adapted from Pilsbry, Naut. IX. 109.
† Adapted from Pilsbry, Naut. IX. 17.

Subfamily ZONITINÆ Pilsbry.

♀System lacking dart-sack and its accessories.

Genus **OMPHALINA** Rafinesque.

Shell umbilicated or perforated, globosely depressed, thin, striated or wrinkled above, smooth below, reddish horn-color, lighter below, shining; aperture large, lunar-ovate; peristome simple, straight, acute, extremities approaching, that of the columella subreflected.

Fig. 29. Animal of *O. fuliginosa*. (Binney).

Animal (of *O. fuliginosa*) nearly twice as long as diameter of the shell, blackish or bluish-black; darkest on the head, neck and eye-peduncles, eye-peduncles short in proportion to the length of the animal and set widely apart. Respiratory foramen in the angle formed by the junction of the peristome with the body whorl. Base of foot whitish, the locomotive band defined by two very fine lines or furrows. A double marginal furrow runs along the side of the foot from the head nearly to the posterior, where it passes upwards and joins that from the opposite side, leaving posteriorly a flattened, rounded extremity, somewhat prominent and glandular, in the centre of which is a longitudinal sinus, fissure or mucus pore.

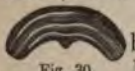


Fig. 30. Jaw of *O. fuliginosa* (Binney.)

Jaw arcuate, ends acuminated, often recurved, sometimes blunt; anterior surface without ribs, cutting margin with a beak-like projection.

Dentition: centrals with base of attachment longer than wide, with lateral expansions at the corners of the lower margins; laterals of the same type as the centrals, but rendered asymmetrical by the depression of the inner, lower, lateral expansion of the base of attachment and the inner side-cusp and cutting point; marginals with narrow, lengthened basal plates, either unicuspid and thorn-like or bicuspid by elevation of outer on middle cusp.

Fig. 31. Dentition of *O. fuliginosa*. (Binney.)

KEY TO THE SPECIES OF *OMPHALINA*.

I. Shell larger, 26 mm. in diam., umbilicus wide.....*fuliginosa*.
II. Shell smaller, 15 mm. in diam, umbilicus minute.....*inornata*.

Fig. 32. *O. fuliginosa*. (Binney.)

OMPHALINA FULIGINOSA (Griffith).

Shell rather large, thin, depressed, chestnut brown sometimes almost black, shining and wrinkled; whorls 4½, rapidly increasing, the last whorl very voluminous and expanding transversely toward the aperture; suture slightly impressed; aperture very oblique, ample, lunate-ovate; peristome simple, thin, with a light testaceous deposit within, extremities approaching that of the columella somewhat reflected; umbilicus deep and much expanded.

Alt. 13, greater diam. 26, lesser 22 mm.
Helix fuliginosa, Griffith, Bost. Jour. Nat. Hist., III., 417, pl. XXIV, (1840).
Zonites ———, W. G. Binney, Man. Am. Land Shells, 207, fig. 217, (1885).
Helix ———, Sager, Doc. H. Rep. Mich., 1839, 420, separate, 14.
—— ———, Miles, Rep Geol. Surv. Mich., 235, (1861).
Hyalina ———, Currier, Shell-bearing Moll. Mich., 4, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 5, (1881).
Zonites fuliginosus, Walker, Rev. Moll. Fauda Mich., 16, (1894).

Apparently rare and local. Reported from Ottawa, Kent, Genesee, Tuscola, Lapeer, Washtenaw and Monroe counties, which indicates a range across the southern part of the state.

Fig. 33. *O. inornata.* (Binney.)

OMPHALINA INORNATA (Say).

Shell depressed; light yellowish horn-color, smooth, shining, obscurely striate; whorls 4½; suture slightly impressed; aperture transverse, slightly oblique, broader than high, with a white, callus deposit just within the margin; lip thin, acute, its ends somewhat converging, the basal extremity impinging on the small umbillicus; base somewhat flattened, indented in the centre. Alt. 8½, diam. 15 mm.

Helix inornata, Say, Jour. A. N. S. P., II., 371, (1821).
Zonites inornatus, W. G. Binney, Man. Am. Land Shells, 217, fig. 229, (1885).
Helix inornata, Sager, Doc. H. Rep. Mich. 1839, 420, separate p. 14.
—— ———, Miles, Rep. Geol. Surv. Mich., 235, (1861).
Zonites inornatus, Walker, Rev. Moll. Fauna Mich., 16, (1894).

This species, after escaping observation for forty years, has recently been discovered by Mr. W. Miller, who has submitted specimens found near Grand Rapids. He also reports it from Hart, Oceana county, but the specimens from the latter locality have been lost or mislaid, and consequently have not been authenticated.

It is a well marked species and easily distinguished from *O. fuliginosa* by its smaller size and minute umbillicus.

Genus **VITRINA** Draparnaud.

Shell external, imperforate, pellucid, glossy, depressed: spire short; whorls 2-3, rapidly increasing, the last wide; aperture large; peristome thin.

Fig. 34. Animal of *Vitrina.* (Binney.)

Animal heliciform, obtuse before, pointed behind-mantle, posterior with an anterior prolongation covering the back, and with a process or prolongation which is reflected backward upon the shell. A distinct locomotive disk. No caudal mucus pore. Respiratory orifice subcentral, on the right side of the mantle, under the peristome of the shell. Anal orifice contiguous to the respiratory orifice.

Fig 35. Jaw of *V. limpida.* (Binney.)

Jaw highly arched, ends acuminated, blunt; cutting margin with a prominent, bead-like median projection. Dentition; centrals with a quadrangular base of attachment, longer than broad, tricuspid; laterals arranged in straight transverse rows, asymmetrical; marginals with sole-shaped base of attachment and aculeate, bifid cutting-points.

Fig. 36. Dentition of *V. limpida* (Binney.

VITRINA LIMPIDA Gould.

Fig 37. *V. limpida.* (Binney.)

Shell imperforate, globosely depressed, thin, fragile, transparent, shining; whorls 2½-3; scarcely convex, with very minute lines of increase, the last whorl large and very much expanded; suture not much impressed, aperture large, subovate, peristome thin and acute.

Alt. 3, diam. 6 mm.

Vitrina limpida, Gould, Agassiz's Lake Superior, 243, (1850).
——— ———, W. G. Binney, Man. Am. Land Shells, 177, fig. 170, (1885).
——— ———, Walker, Rev. Moll. Fauna Mich., 16, (1894).

A northern species, reported from Isle Royale, Ontonagon county, Lime Island in the St. Mary's river, Charlevoix, Traverse City, and Crystal Lake, Benzie county.

Genus **VITREA** Fitzinger.

Fig. 38. Animal of *V. cellaria.* (Binney.)

Shell small, thin, fragile, shining, hyaline, smooth, convexly depressed, last whorl not descending at the aperture, umbilicate or imperforate; aperture lunate; peristome thin and sharp.

Animal black or bluish-black on the upper parts, lighter, sometimes wholly white posteriorly. Foot long and narrow. Jaw arcuate, ends attenuate, pointed or rounded; concave margin with a median rounded projection. Dentition as in *Omphalina*.

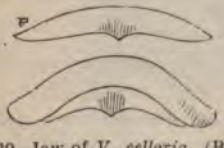


Fig. 39. Jaw of *V. cellaria.* (Binney.)

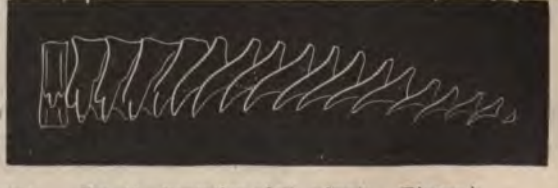


Fig. 40. Dentation of *V. cellaria.* (Binney.)

KEY TO THE SECTIONS OF *VITREA*.

I. No internal teeth.
  a. Surface smooth, spiral lines, when present, very minute...*Vitrea* s. s.
  aa. Surface minutely striate, retriculated with impressed, spiral lines.....*Striatura.*
  aaa. Surface with sharply defined, impressed, radial lines.....*Glyphyalina.*
II. With internal, radial rows of teeth.....*Paravitrea.*

KEY TO THE SPECIES OF *VITREA*.

I. Body-whorl with two or three rows of internal teeth..... *Multidentata.*
II. No internal teeth in body-whorl.
a. Surface with impressed, radiating lines.
b. Imperforate or nearly so..... *indentata.*
bb. Umbilicate..... *rhoadsi.*
aa. Surface with microscopic revolving lines.
b. Body-whorl rapidly widening toward the aperture, base flattened, spire subplanulate, brownish horn-colored, diameter 5 mm. ..... *wheatleyi.*
bb. Body-whorl regularly increasing, spire slightly elevated, base rounded, light steel gray, diameter 2½ mm..... *ferrea.*
aaa. Surface smooth, polished.
b. Diameter exceeding 10 mm., base bluish-white, thickened within ..... *cellaria.*
bb. Diameter 4-5 mm. No basal thickening.
c. Umbilicus small, dark horn-colored..... *hammonis.*
cc. Umbilicus wider, almost colorless..... *binneyana.*

Section **VITREA** s. s.

Shell smooth and polished; spiral lines, when present, very minute.

VITREA CELLARIA (Muller).

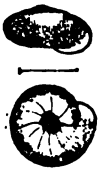


Fig. 41. *V. cellaria* (Binney.)

Shell very much depressed, thin, fragile, pellucid; greenish horn-color above, paler beneath, smooth, highly polished; whorls 5, slightly rounded; aperture oblique, transverse, umbilicus moderate, regularly rounded, deep; base rounded, thickened within by a testaceous, bluish-white deposit; peristome simple, acute.

Alt. 5, greater diam. 13, lesser 11½ mm.

Helix cellaria, Muller, Verm. Hist., II., 28, (1774).
Zonites cellarius, W. G. Binney, Man. Am. Land Shells, 448, fig. 493, (1885).
——— ———, Walker, Rev. Moll. Fauna Mich., 16, (1894)

A European species that has been locally introduced with foreign plants and is usually found in quantiites where it occurs. Reported from Detroit, Alma, Gratiot county, Bay City and Muskegon. Easily distinguished from allied species by its larger size and the callus deposit within the aperture, which renders the base opaque and bluish-white.

VITREA HAMMONIS (Strøm).

Fig. 42. *V. hammonis* (Binney.)

Shell narrowly umbilicated, small, depressed-conic, thin, fragile; pale or brownish horn-color, wrinkled, shining; whorls 4, the last rapidly enlarging toward the aperture; aperture transversely rounded; peristome simple, its edge rather thickened, not acute; base rounded.

Alt. 2, greater diam. 5, lesser 4⅔ mm.

Helix hammonis, Strom, Trondh. Selsk, Skrift, III., 425, pl. IV., fig. 16, (1765).
Zonites viridulus, W. G. Binney, Man. Am. Land Shells, 64, fig. 21, (1885).
Helix electrina, Miles, Rep. Geol. Surv. Mich., 235, (1861).
Hyalina ———, Currier, Shell-bearing Moll. Mich., 4, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 5, (1881).
Zonites radiatulus, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Common and of general distribution, although not as abundant as its associated species, *Z. arborea*. The identity of the American species with that described by Ström has been only recently established, and it has been usually known of *V. electrina* (Gld.), *viridula* (Mke)., or *radiatula* (Ald.).

Careful attention is required to distinguish this species from three others, which are of about the same size and same general appearance, viz.: *V. indentata*, *V. wheatleyi* and *Z. arborea*. But when once recognized, the difference between them will be found to be constant and well marked.

V. hammonis is characterized by its more pointed spire, slightly impressed suture, rapidly enlarging body whorl and narrow umbilicus, perfectly smooth surface with neither radiating nor revolving, impressed lines. *V. indentata* is imperforate and has distant, impressed radiating lines which are quite distinct from the growth-lines. It is also lighter colored.

In *V. wheatleyi*, the umbilicus is wider and rapidly increases in size toward the aperture, which gives it an irregular shape; the base is somewhat flattened; the aperture is more transverse, and the last whorl is slightly descending at the aperture. Surface with microscopic revolving, impressed lines.

Zonitoides arborea differs in the wider umbilicus, more depressed spire, and its regularly increasing, more numerous, and more convex whorls, which are separated by a well marked suture. Surface with very fine, impressed, revolving lines.

VITREA WHEATLEYI (Bland).

Fig. 43. *V. wheatleyi*. (Binney.)

Shell umbilicated, depressed, thin, shining, pellucid; brownish horn-colored, finely striated, striæ decussated by very minute spiral lines; spire subplanulate; suture slightly impressed; whorls convex, the last more convex at the base, rapidly increasing, at the aperture scarcely descending; umbilicus pervious, rapidly widening toward the aperture; aperture depressed, obliquely lunate; peristome simple, acute, the margins approximating joined by a thin callus.

Alt. 2, greater diam. 5, lesser 3½ mm.

Zonites wheatleyi, Bland, Ann. N. Y. Acad. N. S., II., 368, fig. 1, (1883).
——— ———, W. G. Binney, Man. Am. Land Shells, 222, fig. 237, (1885).
Helix limatula, Miles, Rep. Geol. Surv. Mich., 235, (1861).

This species has only been recently recognized as a member of our fauna. It has been found in Tuscola, Kalamazoo, Kent, Benzie and Grand Traverse counties, which indicate a general distribution in the northern and western portion of the lower peninsula.

It is peculiar in the oval shape of the umbilicus, resulting from the rapid increase in the size of the body whorl during the last half of its growth.

VITREA BINNEYANA (Morse).

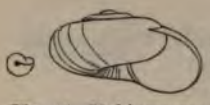


Fig. 44. *V. binneyana.* (Binney.)

Shell broadly umbilicated, subglobose, transparent, almost colorless, shining, smooth, with microscopic wrinkles of growth and still more delicate, oblique wrinkles; spire not much elevated; whorls about 4, rounded, gradually increasing, the last globose; aperture oblique, subcircular, large; peristome simple, acute.

Alt. 2, diam. 4 mm.

Hyalina binneyana, Morse, Jour. Portl. N. H. Soc., I., 13, fig. 25-6, (1864).
Zonites binneyanus, W. G. Binney, Man. Am. Land Shells, 180, fig. 174, (1885).
——— ———, Walker, Rev. Moll. Fauna Mich., 16, (1894).

A northern species of general distribution north of Iosco county. It has also been reported from Kent county. Easily distinguished by its open umbilicus, smooth surface and white color.

Section **STRIATURA** Morse.

Fig. 45. Jaw of *V. ferrea.* (Binney.)

Shell small, striate, reticulated with impressed, spiral lines, thin, translucent, without teeth in the aperture.

Jaw almost smooth, with a median furrow and notch; central tooth of radula very large.

Fig. 46. Dentition of *V. ferrea.* (Binney.)

VITREA FERREA (Morse).

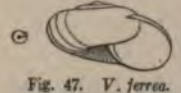


Fig. 47. *V. ferrea.* (Binney.)

Shell umbilicated, depressed-globose; transparent, of a light steel-gray color, not shining, marked with very delicate incremental wrinkles and microscopic revolving lines; reticulating the surface; spire slightly elevated; whorls 3, the last rapidly enlarging, globose; suture distinct and deeply channeled near the apex; aperture large, transversely subcircular; peristome simple, acute, its extremities not approaching, that of the columella scarcely subreflected.

Alt. 1¼, greater diam. 2½ mm.

Striatura ferrea, Morse, Jour. Portl. N. H. Soc., I., 17, figs. 36-40, (1864).
Zonites ferreus, W. G. Binney, Man. Am. Land Shells, 181, fig. 175, (1885).
——— ———, Walker, Rev. Moll. Fauna Mich., 16, (1894).

A northern species of general distribution. Gratiot county is the most southerly locality reported. The characteristic sculpture of the surface can be seen only with the microscope.

Section **GLYPHYALINA** Von Martens.

Upper surface of the shell marked with sharply defined, radial impressions.

VITREA INDENTATA (Say).

Fig. 48. *V. indentata* (Binney.)

Shell imperforate, flattened, thin, pellucid; epidermis highly polished, corneous; whorls rather more than 4, rapidly enlarging, with regular, subequal distant, radiating, impressed lines, which on the body whorl extend to the centre of the base, outer whorl expanding toward the aperture; suture well impressed; aperture rather large, transverse; peristome simple, acute, very thin, at its inferior extremity terminating at the centre of the base of the shell; umbilicus none, but the umbilical region is indented.

Alt. 2½, greater diam. 5, lesser 4½ mm.

Helix indentata, Say, Jour. A. N. S. P., II., 372, (1822).
Zonites indentatus W. G. Binney, Man. Am. Land Shells, 62, fig. 15, (1885).
Helix indentata, Miles, Rep. Geol. Surv. Mich., 235, (1861).
Hyalina indentata, Currier, Shell-bearing Moll. Mich., 4, (1868).
——— ——— DeCamp, Shell-bearing Moll. Mich., 5, (1881).
Zonites indentatus, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Generally distributed in both peninsulas but not as common as either *V. hammonis* or *Z. arborea*. Distinguished by the impressed radiating lines and imperforate base.

VITREA RHOADSI Pilsbry.

Shell umbilicate, depressed, thin, pellucid, corneous; surface polished with numerous impressed radiating lines; whorls about 4, rapidly enlarging, suture impressed, aperture rather large, transverse; lip simple, acute.

Fig. 49. *V. rhoadsi*. ×5½.

Alt. 2½, diam. 4.8 mm.

Vitrea rhoadsi, Pilsbry, Naut. XII., p. 101, (1899).

This recently described species resembles *V. indentata* in the impressed radiating lines, which sculpture the surface, but differs in being distinctly umbilicated. It has thus far been reported only from the Grand Traverse region at Charlevoix, Petoskey and Carp Lake, Emmet county.

Section **PARAVITREA** (Pilsbry).

Shell depressed or discoidal, perforate or narrowly umbilicate, composed of numerous closely coiled whorls, usually grooved radially above; thin and fragile; internally having obliquely radial laminæ or rows or pairs of teeth at intervals of a third of a whorl, some or all of them often wanting, especially in old individuals.

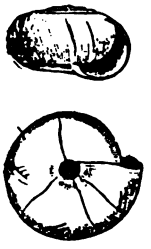


Fig.50. *G.multidentata* (Binney.) ×4.7.

VITREA MULTIDENTATA (Binney).

Shell umbilicated, depressed, flattened above, very thin, pellucid; yellowish horn-color, shining; whorls 6, narrow, slightly convex, slowly increasing in diameter, very closely ribbed striate above, beneath smoother; suture impressed; aperture narrow extending to the umbilicus; peristome acute; umbilicus very small, rounded; base convex, indented around the umbilicus; two or more rows of very minute white teeth radiating from the umbilicus on the base of the last whorl. Alt. 1½, greater diam. 3¼ mm.

Helix multidentata, Binney, Bost. Jour. Nat. Hist., III., 425, pl. XXII., fig. 5, (1840).
Zonites multidentatus, W. G. Binney, Man. Am. Land Shells, 183, fig. 180, (1885).
Gastrodonta multidentata, Currier, Shell-bearing Moll. Mich., 4, (1868.)
————— —————, DeCamp, Shell-bearing Moll. Mich., 5, (1881).
Zonites multidentatus, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Rare and local. It has been found in Marquette, Ontonagon, Emmet, Grand Traverse, Benzie, Iosco, Saginaw, and Kalamazoo counties, which indicates a general distribution throughout the state.

Genus **EUCONULUS** Reinhardt.

Shell imperforate or very narrowly perforate, turbinate, arcti-spiral; whorls 5-6, rather convex; aperture depressed-lunar; the penultimate whorl strongly excided, somewhat oblique. Peristome with margins separated.

Animal bluish-black on the head, neck and eye peduncles, lighter on the sides and base; foot very narrow, threadlike, a distinct caudal mucus-pore.

Fig 51. Jaw of *Euconulus* (Binney.)

Jaw arcuate, ends attenuated; anterior surface smooth, concave, margin smooth, with an obtuse median projection. Dentition as usual in the family, but is peculia in the bifurcation of all the marginal teeth.

Fig. 52. Dentition of *Euconulus*. (Binney.)

KEY TO THE SPECIES OF *EUCONULUS*.

I. Whorls 5 or less, wider and spire less elevated than in II., the peripheral angle in middle of whorl..... *fulvus.*
II. Whorls 6, very narrow, spire more elevated, peripheral angle above the middle of the whorl..... *chersinus polygyratus.*

EUCONULUS FULVUS (Muller).

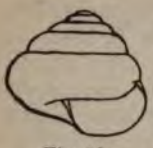


Fig. 53.
E. fulvus.×5¾.

Shell subperforate, subconical, thin, pellucid; smooth, shining, minutely striated, amber-colored; whorls 5 rounded above, the last one distinctly angular in front, the angle disappearing on the latter part of the whorl; suture distinct and deep; aperture transverse, narrowly lunate, rounded below, peristome simple, acute; base convex, indented.

Alt. 3, greater diam. 4, lesser 3½ mm.

Helix fulva, Draparnaud, Hist. Nat. Moll. France, 81, pl. VII., fig. 12-3, (1805).
Zonites fulvus, W. G. Binney, Am. Land Shells, 67, fig. 26, (1885).
Helix chersina, Miles, Rep. Geol. Surv. Mich., 235, (1861).
Conulus ———, Currier, Shell-bearing Moll. Mich., 4, (1865).
——— ———, DeCamp, Shell-bearing Moll. Mich., 5, (1881).
Zonites fulvus, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Common and of general distribution in both peninsulas. This species is distinguished from *E. chersinus polygyratus* by its more conical, less elevated spire, fewer, wider whorls and peripheral angle, the aperture is more transverse and more rounded below.

E. fulvus mortoni Jeffr., was cited in my Terr. Moll. of Mich. (1894), from East Saginaw. The recent receipt of authentic examples from England has shown that the identification was erroneous.

EUCONULUS CHERSINUS POLYGYRATUS (Pilsbry).

Fig. 54.
E. chersinus polygyratus ×6¼.

Shell minutely perforate, subglobose elevated, conical, thin, pellucid, smooth, shining, deep, brownish amber-colored; whorls 6 or more, rounded, very narrow; the last bluntly but decidedly angular in front, the angle above the middle of the whorl, base peculiarly sloping below the periphery; spire elevated, outline convex; upper surface with lustre of silk; base glossy, with a silky band around the outer margin; suture distinct and deep; aperture transverse, very narrow; peristome simple, acute.

Alt. 2.2, diam. 3 mm.

Conulus chersinus polygyratus, Pilsbry, Naut. XII., 116, (1899).

Not as common as the preceding species, but of general distribution in both peninsulas.

The narrow whorls and peculiar base of this species result in making the aperture narrower and less transverse than in typical *fulvus*. The convex, dome-shaped spire and more numerous whorls are also very characteristic, when once recognized.

Subfamily ARIOPHANTINÆ Pilsbry.

☥ System bearing a long dart-sack, surmounted by one or more coronal glands, and usually containing a slender curved dart.

Genus **ZONITOIDES** Lehman.

Shell depressed or subdiscoidal, umbilicate, smooth or ribbed, striate or costulate, shining, pellucid, corneus, aperture obliquely lunate. No internal teeth or callus.

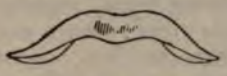


Fig.55. Jaw of *Z. arborea.* (Binney.)

Jaw long, narrow, arcuate with ends pointed or rounded, lower margin smooth, with a wide median impression. Dentition as usual in the family.

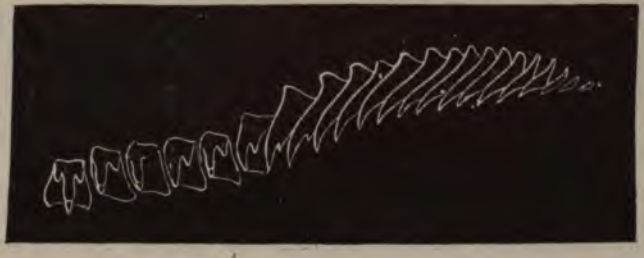


Fig. 56. Dentition of *Z. arborea.*—(Binney.)

Section **ZONITOIDES** s. s.

Surface polished.

KEY TO THE SPECIES OF *ZONITOIDES. s.s.*

I. Umbilicus wide, diameter 7½ mm.....*nitida.*
II. Umbilicus moderate, diameter 5 mm.....*arborea.*

ZONITOIDES NITIDA (Muller).

Fig. 57. *Z. nitida* (Binney.)

Shell widely umbilicate, depressed, moderately convex above and concave below, thin, shining, uniform yellowish horn-color; delicately striate; whorls 5 or more, convex; suture impressed; outer whorl large and obtusely angular at the periphery; aperture oblique, lunate, rounded below; peristome simple.

Alt. 3⅔, greater diam. 7½, lesser 6 mm.

Helix nitida, Muller, Hist. Verm., II., 32, (1774).
Zonites nitidus, W. G. Binney, Man. Am. Land Shells, 60, fig.12, (1885).
Helix hydrophila, Miles, Rep. Geol. Surv. Mich., 235, (1861).
Hyalina nitida, Currier, Shell-bearing Moll. Mich., 4, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 5, (1881).
Zonites nitidus, Walker, Rev. Moll. Fauna Mich., 16, (1894).

A common and abundant species of general distribution. It frequents the muddy banks of streams, where it is associated with the *Succineas, Pomatiopsis* and other semi-amphibious species. When alive, it is easily identified, not only by its greater size, but by the dark color of the animal which makes the shell appear to be black, when cleaned it is distinguished from *Z. arborea* on the one hand by its greater size and wider umbilicus and from *V. cellaria,* on the other, by its more convex whorls and lack of the basal callus-deposit.

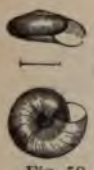


Fig. 58. *Z. arborea.* (Binney.)

ZONITOIDES ARBOREA (Say).

Shell umbilicated, depressed, very slightly convex, thin, pellucid; amber-colored, smooth with microscopic revolving lines, shining; whorls 4-5, with very minute oblique microscopic striæ; suture well impressed; aperture transversely rounded; peristome thin, acute; umbilicus moderate, well developed, round and deep.

Alt. 2¾, greater diam. 5, lesser 4⅓ mm.

Helix arborea, Say, Nich. Encycl. pl. IV., fig. 4, (1817).
Zonites arboreus, W. G. Binney, Man. Am. Land Shells, 61, fig. 13, (1885).
Helix ———, Sager, Doc. H. Rep. Mich., 1839, 420, separate, 14.
——— *arborea*, Miles, Rep. Geol. Surv. Mich., 235, (1861).
Hyalina ———, Currier, Shell-bearing Moll. Mich., 4, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 5, (1881).
Zonites arboreus, Walker, Rev. Moll. Fauna Mich., 16, (1894).

This is the most common species of the family, and is found abundantly everywhere. Usually associated with *Vitrea hammonis*, *V. indentata*, *V. wheatleyi*, and *Zonitoides nitida*. For the differential characters, see the keys and the remarks under the several species cited.

Subgenus PSEUDOHYALINA Morse.

Surface closely striate, ribbed or costulate.

KEY TO THE SPECIES OF *PSEUDOHYALINA*.

I. Surface striate.
  a. Shell larger, 5.5 mm. in diameter..... *limatula.*
  aa. Shell minute, 2.5 mm. in diameter..... *minuscula.*
II. Minute, diameter 2½ mm. or less, surface ribbed or costulate.
  a. Surface ribbed, ribs oblique to lines of growth..... *exigua.*
  aa. Surface costulately folded and reticulated with longitudinal ribs, very minute..... *milium.*

ZONITOIDES LIMATULA Ward.

Fig 59. *Z. limatula*. ×4½.

Shell small, widely umbilicated, depressed, thin, greenish-white; whorls rather more than 4, convex, with fine, oblique, parallel striæ, becoming subobsolete in the base; suture well impressed; aperture subcircular; lip thin, acute, its ends approaching; umbilicus round and deep, exhibiting all the volutions.

Alt. 2.5, diam. 5.5 mm.

Helix *limatula*, Ward, Bost. Jour. Nat. Hist., III., 434, pl. XXI., fig. 2, (1840).
Zonites *limatulus*, W. G. Binney, Man. Am. Land Shells, 220, fig. 233, (1885).
Helix *limatula*, Miles, Rep. Geol. Surv. Mich., 235, (1861).
Pseudohyalina ———, Currier, List Shell-bearing Moll. Mich., 6, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 5, (1881).
Zonites *limatulus*, Walker, Rev. Moll. Fauna Mich., 16, (1894).

This is apparently one of the rarest of Michigan species. None of the citations have been authenticated, and several of them have been proven to be erroneous. A single specimen in the collection of Mr. L. H. Streng, from Grand Rapids, is the only Michigan example that has thus far passed under observation. It is easily distinguished by its color, wide umbilicus and striate surface.

Fig. 60. *Z. minuscula.* (Binney.)

ZONITOIDES MINUSCULA (Binney).

Shell umbilicated, minute, depressed convex; whitish; whorls 4, convex, slowly increasing in diameter, very finely striate; suture deep; aperture nearly circular; peristome thin, acute; umbilicus large, deep and exhibiting the volutious; base rounded. Alt. 1, greater diam. 2½, lesser 2⅓ mm.

Helix *minuscula*, Binney, Bost. Jour. Nat. Hist., III., 435, pl. XXII., fig. 4, (1840).
Zonites *minusculus*, W. G. Binney, Man. Am. Land Shells, 63, fig. 18, (1885).
Helix *minuscula*, Miles, Rep. Geol. Surv. Mich., 236, (1861).
Pseudohyalina ———, Currier, Shell-bearing Moll. Mich., 5, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 6, (1881).
Zonites *minusculus*, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Common and of general distribution in the lower peninsula. Has not yet been reported from the upper peninsula. A well marked little species, characterized by its depressed form and large umbilicus.

ZONITOIDES EXIGUA (Stimpson).

Fig. 61. *Z. exigua.* ×6.4. (Binney.)

Shell broadly umbilicated, depressed, pellucid, greenish horn-color, spirally striate and with distant longitudinal oblique ribs; spire very low; apex smooth; whorls 3½, convex, the last rounded; aperture oblique, transversely rounded, remote from the axis; peristome simple, acute.

Alt. ½, greater diam. 2½ mm.

Helix *exigua*, Stimpson, Proc. B. S. N. H., III., 175, (1850).
Zonites *exiguus*, W. G. Binney, Man. Am. Land Shells, 181, fig. 177, (1885).
Pseudohyalina *exigua*, Currier, Shell-bearing Moll. Mich., 5, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 6, (1881).
Zonites *exiguus*, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Fig. 62. Sculpture of *Z. exigua*. (Binney.)

Generally distributed in the northern part of the state. The only locality reported south of Lake county is Grand Rapids. Distinguished from *Pyramidula asteriscus*, the only species with which it is likely to be confounded, by its larger size and the position of the ribs, which are oblique to the lines of growth.

ZONITOIDES MILIUM (Morse).

Fig. 63. *Z. milium*. ×10¾. (Binney.)

Shell widely umbilicated, depressed, transparent, shining, greenish-white, distinctly and regularly striate above, with microscopic revolving lines, more conspicuous below; spire very low; whorls 3, rounded, rapidly increasing; aperture very oblique, semi-circular, remote from the axis; peristome simple, acute.

Alt. ½, greater diam. 1½ mm.

Helix milium, Morse, Proc. B. S. N. H., VII., 28, (1859).
Zonites ———, W. G. Binney, Man. Am. Land Shells, 66, fig. 23, (1885).
——— ———, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Owing to its minuteness this species is apparently rare, but evidently has a general distribution throughout the state. "The surface of the shell is raised in numerous costal folds, frequently anastomosing; longitudinal ribs reticulate the surface and render the folds so crenulated that in certain lights the shell appears as if ornamented with strings of beads. This peculiar character disappears at the base of the shell and is replaced by revolving lines and regular lines of accretion."—(Morse).

Genus **GASTRODONTA** Albers.

Shell subperforate or umbilicated, orbicularly convex or depressed, light horn-color, finely and obliquely striate, sometimes glassy; whorls 5-7, aperture lunate, base furnished with internal teeth, not reaching the margin, or thickened by an internal deposit of callus; peristome simple acute.

Animal bluish-black or dark slate-color above, paler on the posterior extremity and base; foot narrow and long; eye-peduncles long and slender; a distinct locomotive disk; pedal grooves terminating in a longitudinal mucus pore.

Fig. 64. Animal of *G. ligera*. (Binney.)

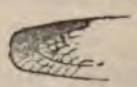


Fig. 65. Tail of *G. suppressa*. (Binney.)

Fig. 66. Jaw of *G. ligera*.

Jaw strongly arcuate, ends rounded; anterior surface striated; concave margin with a well developed median projection.

Dentition as usual in the family.

Fig. 67. Dentition of *G. intertexta*. (Binney.)

KEY TO THE SPECIES OF *GASTRODONTA*.

I. Aperture with internal teeth on base of shell.....*suppressa*.
II. Aperture edentulous, callus deposit on base of shell.
a. Spire somewhat elevated, acute.
b. Surface distinctly obliquely striate, not shining.....*intertexta*.
bb. Surface shining, very finely striate.....*ligera*.
aa. Spire depressed, obtuse, surface shining.....*demissa*.

GASTRODONTA INTERTEXTA (Binney).

Fig. 68. *G. intertexta*. (Binney.)

Shell perforated, subpyramidal; yellowish horn-color; whorls 6-7, slightly angled, closely and finely striate; striæ cut by very minute spiral lines; usually with a narrow, light-colored band and an ill-defined brownish band below it, frequently, however, unicolored; aperture rounded, a little transverse; peristome thin, thickened within by a callus deposit, umbilical perforation small; base whiter than the upper surface.

Alt. 10, greater diam. 15, lesser 13½ mm.

Helix intertexta, Binney, Bost. Jour. Nat. Nist., III., 413, pl. XX., fig. 2, (1840).

Zonites intertextus, W. G. Binney, Man. Am. Land Shells, 214, fig. 226, (1885).

Rare in Michigan. Sanilac county is the only known locality. Distinguished from *G. ligera* by its greater size, coarse, unpolished, striate surface and angulated body whorl.

GASTRODONTA DEMISSA (Binney).

Fig. 69. *G. demissa*. (Binney.)

Shell perforated, depressed-convex; yellowish horn-color, shining; whorls 6, minutely striate; spire obtusely convex; suture impressed; aperture transverse, not large, slightly oblique, a white callus deposit on the base; peristome thin, acute; base rather flat, smooth; umbilical region somewhat impressed.

Alt. 6, greater diam. 11½, lesser 10½ mm.

Helix demissa, Binney, Bost. Jour. Nat. Hist., IV., 361, pl. XVI, fig. 16, (1843).

Zonites demissus, W.G. Binney, Man. Am. Land Shells, 212, fig. 223, (1885).

Very rare. Kent county is the only locality reported. Very similar to *G. ligera* in color and texture, but differs in size and shape, being more depressed and the spire being convex with an obtuse apex. *G. ligera* is larger, more strongly striate, the body-whorl is more ventricose and the spire more elevated and acute.

GASTRODONTA LIGERA (Say).

Fig. 70. *G. ligera.* (Binney.)

Shell perforated, orbicularly convex; yellowish horn-color, shining; whorls 7, finely and closely striate; smooth below; spire rather elevated, acute; suture not much impressed; aperture semi-lunate, rounded; peristome thin, acute; aperture thickened within by a white callus deposit on the base and outer wall.

Alt. 10, greater diam. 15, lesser 13 mm.

Helix *ligera*, Say, Jour. A. N. S. P., II., 157, (1821).
Zonites *ligerus*, W. G. Binney, Man. Am Land Shells, 213, fig. 225, (1885).
Helix *ligera*, Sager, Doc. H. Rep. Mich., 1839, 420, separate, 14.
——— ———, Miles, Rep. Geol. Surv. Mich., 235, (1861).
Mesomphix ———, Currier, Shell-bearing Moll. Mich., 4, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 5, (1881).
Zonites *ligerus*, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Generally distributed in the southern part of the state.

GASTRODONTA SUPPRESSA (Say).

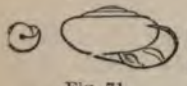


Fig. 71. *G. suppressa.* (Binney.)

Shell subperforated, subconical; shining, pale yellowish horn-color; spire somewhat pointed or obtuse; whorls 7-8, regularly and slowly increasing in diameter, striate above, smoother below; suture distinctly impressed; aperture transverse not much expanded; peristome simple, acute, thickened by a white callus deposit within, with one or two lamelliform, parallel teeth on the base; base flat, indented in the centre, near the aperture yellowish white and opaque; umbilicus small and rounded in young shells, obsolete or diminishing to a mere perforation when adult.

Alt. 5, greater diam. 8 mm.

Helix *suppressa*, Say, New Haven Diss., II., 229, (1829).
Zonites *suppressus*, W. G. Binney, Man. Am. Land Shells, 225, fig. 241, (1885).
——— ———, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Apparently rare and local. Washtenaw, Genesee and Kent counties are the only localities reported.

Family LIMACIDÆ.

Animal naked, with a thin, internal, shelly, non-spiral plate; no caudal mucus pore; foot margin narrow. Jaw arched, without ribs, with a median projection to the cutting edge. Lingual membrane with the rows of teeth horizontal or slightly oblique; marginal teeth with narrow basal plates, either unicuspid and thornlike, or bicuspid by elevation of outer on middle cusp.

Genus AGRIOLIMAX Morch.

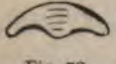


Fig. 72. Jaw of *A. agrestis.* (Binney.)

Animal shortly carinate behind. Jaw arcuate with slightly attenuated but blunt ends; anterior surface smooth, cutting margin with a decided beak-like projection. Central tooth of radula tricuspid; laterals bicuspid, in a straight row; marginals in oblique rows. Eggs orbicular.

Fig. 73. Dentition of *A. agrestis.* (Binney.)

KEY TO THE SPECIES OF *AGRIOLIMAX.*

I. Upper surface of body covered with smooth, flat tubercles separated by shallow furrows darker than general body color; respiratory foramen surrounded by a whiteish border; mucus milky white..... *agrestis.*

II. Smaller; tubercles on body more prominent, not flattened, intervening furrows of same color as general surface. No border around respiratory orifice; mucus thin, colorless..... *campestris.*

AGRIOLIMAX AGRESTIS (Linnæus).

Fig. 74. *A. agrestis.* (Binney.)

Body, when in motion, cylindrical, elongated, terminating acutely, tail shortly carinated; foot very narrow; upper surface rugose, rugæ separated by darker colored, anastomosing lines; mantle large, ovate-oblong, rounded at both extremities, concentrically rugose; eye-peduncles elongated, cylindrical, with small ocular bulbs; lower tentacles immediately under them, very short; respiratory foramen posterior, large, surrounded with a whitish border; color varying from whitish through every shade of cinereous and gray to black, and through various shades of yellowish or amber-color to brownish, unicolored or irregularly maculated with small black points; sole sallow-white; mucus milky.

Length 25-50 mm.

Limax agrestis, Linnæus, Syst. Nat. (x), I., 652, (1758).

——— ———, W. G. Binney, Man. Am. Land Shells, 453, fig. 498, (1885).

A European species locally introduced. It has been found at Lansing, Olivet and Lime Island in the St. Mary's river, and is reported from Ann Arbor. Larger than our native species, *A. campestris* and differs externally in the white ring around the respiratory orifice and the darker colored lines, which separate the rugæ on the upper surface of the body and the milky-white mucus which it exudes when touched. Anatomically the two forms are easily separated.

AGRIOLIMAX CAMPESTRIS (Say).

Fig. 75. *A. campestris.* (Binney.)

Color usually various shades of amber or gray, without spots or markings, sometimes blackish; head and eye peduncles smoky; body cylindrical, elongated, terminating in a very short carina at its posterior extremity; mantle oval, fleshy, but little prominent, with fine concentric lines; back covered with prominent, elongated tubercles, intervening furrows of same color as general surface; foot narrow, whitish; respiratory foramen on the posterior dextral margin of the mantle; mucus thin, watery.

Length 25 mm.

Limax campestris, Binney, Proc. B. S. N. H., 1841, 52.
——— ———, W. G. Binney, Man. Am. Land Shells, 237, fig. 257, (1885).
——— ———, Walker, Rev. Moll. Fauna Mich., 16, (1894).
Common and of general distribution.

Family ENDODONTIDÆ.

Shell with opaque brown coloring or flammules, usually rib-striate, the lip thin, unexpanded and sharp. Marginal teeth with wide, short and squarish basal plates, with one or several cusps, the outer cusp never elevated on middle cusp.

KEY TO SUBFAMILIES OF *ENDODONTIDÆ*.

I. Jaw arcuate, its component laminæ compactly soldered together ..... *Endodontinæ*.
II. Jaw arcuate, composed of numerous, separate, rhomboidal, more or less overlapping plates connected by membrane only ..... *Punctinæ*.

Subfamily ENDODONTINÆ Pilsbry.

Jaw formed of overlapping laminæ partially soldered together, or solid and vertically striated.

KEY TO GENERA OF *ENDODONTINÆ*.

I. Shell broadly umbilicate, spire conoidly depressed or flattened, lacking internal teeth on outer wall of the body whorl ..... *Pyramidula*.
II. Shell discoidal, body whorl with internal teeth or outer wall arranged in pairs ..... *Helicodiscus*.

Genus PYRAMIDULA Fitzinger.

Shell openly umbilicated, varying in outline from flattened to conoidal, obliquely coarse often rib-striate, sometimes smooth, sometimes bearded or flammulate. Whorls subcylindrical or convex, the apex generally smooth. Aperture [illegible] simple [illegible]

[illegible] undivided; [illegible] with a distinct [illegible] tail, no [illegible]

[illegible] soldered [illegible] from the [illegible]

Ra[illegible] or [illegible]

Fig. 78. Dentition of *P. alternata*. (Binney.)

KEY TO THE SPECIES OF *PYRAMIDULA*.

I. Shell large, banded or flammulate.
  a. Transversely banded ..... *solitaria*.
  aa. Obliquely flammulate ..... *alternata*.
II. Shell smaller, unicolored, widely umbilicated, ribbed striate.
  a. Spire slightly elevated, obtuse, tooth on base of aperture, diam. 8 mm. ..... *perspectiva*.
  aa. Spire more elevated, umbilicus narrower, no tooth in aperture, diam. 6 mm. ..... *cronkhitei anthonyi*.
  aaa. Spire flat, prominently ribbed, minute ..... *asteriscus*.

Subgenus **PATULA** Held.

Shell rather large and solid; with convex spire and open umbilicus; whorls rounded or carinate at the periphery. Surface striate, ribbed-striate or spirally ribbed; obliquely flamed, unicolored or spirally banded; lip thin, simple.

PYRAMIDULA ALTERNATA (Say).

Fig. 79. *P. alternata*. (Binney.)

Shell broadly umbilicated, orbicularly depressed, thin, smoky horn-colored with red, interrupted, obliquely arranged patches and spots; above closely rib-striate, smoother below; whorls 5½, flattened, often angular at the periphery; aperture oblique, lunately rounded, banded within; peristome simple, acute.

Alt. 10, greater diam. 21, lesser 19 mm.

Helix *alternata*, Say, Nich. Encycl., pl. I., fig. 2, (1817).
Patula ———, W. G. Binney, Man. Am. Land Shells, 255, fig. 269, (1885).
Helix ———, Sager, Doc. H. Rep. Mich., 1839, 420, separate, 14.
——— ———, Miles, Rep. Geol. Surv. Mich., 235, (1861).
Anguspira ———, Currier, Shell-bearing Moll. Mich., 5, (1868).
Anguispira ———, DeCamp, Shell-bearing Moll. Mich., 6, (1881).
Patula ———, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Var. **ALBA** (Tryon).

Anguispira alternata alba, Tryon, Am. Jour. Con., II., 261, (1866).
Anguspira ——— ——, Currier, Shell-bearing Moll. Mich., 5, (1868).
Anguispira ——— ——, DeCamp, Shell-bearing Moll. Mich., 6, (1881).
Patula ——— ——, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Unicolored pale greenish-white.

The typical form is common everywhere. The variety is found occasionally associated with it in the western part of the state, from Kent county to the St. Mary's river. It has not as yet been reported from the eastern part of the state.

PYRAMIDULA SOLITARIA (Say).

Fig. 80. *P. solitaria.* (Binney.)

Shell broadly umbilicated, globosely depressed, coarse, solid, obliquely and finely striate; white to dark reddish horn-color, with from two to three reddish brown revolving bands; whorls 6, convex, suture deep; aperture rounded lunate, pearly white and banded within; peristome simple, acute.

Alt. 15, greater diam. 25, lesser 22 mm.

Helix solitaria, Say, Jour. A. N. S. P., II., 157,(1821).
Patula ———, W. G. Binney, Man. Am. Land Shells, 254, fig. 267, (1885).
Helix ———, Sager, Doc. H. Rep. Mich., 1839, 420, separate, 14.
——— ———, Miles, Rep. Geol. Surv. Mich., 236, (1861).
Anguspira ———, Currier, Shell-bearing Moll. Mich., 5, (1868).
Anguispira ———, DeCamp, Shell-bearing Moll. Mich., 6, (1881).
Patula ———, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Var. **ALBINA** (W. G. Binney).

Lighter colored without bands.

Patula solitaria albino, W. G. Binney, Man. Am. Land Shells, 254, fig. 268, (1885).

Fig. 81. var. *albina.* (Binney.)

Rare in the southeastern part of the state, but apparently more abundant in Kent county, the only reported locality in the western part of the state. Specimens said to have been collected in Chippewa county have also been received. The variety has been reported from Kent county only.

Subgenus **GONYODISCUS** Fitzinger.

Shell rather small, depressed, with low but convex spire and open umbilicus. Apical 1½ whorls smooth, the rest obliquely ribbed-striate, rather tubular, rounded or keeled at the periphery, unicolored. Aperture wide, lunate; lip simple.

PYRAMIDULA PERSPECTIVA (Say).

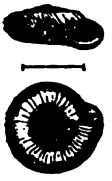


Fig. 82. *P. perspectiva.* (Binney.)

Shell broadly and perspectively umbilicated, orbicular, scarcely convex, above, excavated below; thin, reddish horn-color, regularly ribbed; whorls 6½, gradually increasing; aperture small, lunately subcircular, with a single subprominent tooth on the base of the shell near the columella; peristome simple, acute, its extremities widely separated.

Alt. 3, greater diam. 8, lesser 7½ mm.

Helix *perspectiva*, Say, Jour. A. N. S. P., I., 18, (1817).
Patula ————, W. G. Binney, Man. Am. Land Shells, 260, fig. 276, (1885).
Helix ————, Sager, Doc. H. Rep. Mich., 1839, 420, separate, 14.
——— ————, Miles, Rep. Geol. Surv. Mich., 236, (1861.)
Patula ————, Currier, Shell-bearing Moll. Mich., 5, (1868).
——— ————, DeCamp, Shell-bearing Moll. Mich., 6, (1881).
Pyramidula ————, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Generally distributed south of the Saginaw-Grand valley and northerly on the western side of the state to the Grand Traverse region. Distinguished from *P. cronkhitei anthonyi* by its greater size, coarser striæ, wider umbilicus and the tooth within the aperture near the base of the columella.

PYRAMIDULA CRONKHITEI ANTHONYI Pilsbry

Fig. 83. *P. cronkhitei anthonyi.* (Binney)

Shell widely umbilicated, orbicularly convex, thin, brownish horn-color; closely-ribbed striate; whorls 4, flattened above, rounded below, the last rather wide, aperture sub-circular; peristome simple, acute, its terminations approaching.

Alt. 3, greater diam. 6, lesser 5½ mm.

Pyramidula *cronkhitei anthonyi*, Pilsbry Proc. A. N. S. P. 1906, 153.
Patula *striatella*, W. G. Binney, Man. Am. Land Shells, 69, fig. 28, (1885).
Helix ———, Miles, Rep. Geol. Surv. Mich., 236, (1861).
Patula ———, Currier, Shell-bearing Moll. Mich., 5, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 6, (1881).
Pyramidula ———, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Var. **ALBINA** "Morse," Ckll.

Greenish white, otherwise similar to the type.
Patula *striatella albina*, "Morse," Cockerell, Naut. III., 102, (1890).
Pyramidula ——— *alba*, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Var. CATSKILLENSIS (Pilsbry).

Umbilicus wider and periphery distinctly angulated.
Pyramidula striatella catskillensis, Pilsbry, Naut. XII., 86, (1898.)
The typical form is very abundant in all parts of the lower peninsula, Isle Royale being the only recorded locality in the upper peninsula. The variety, *albina*, has been found only at Mackinac Island and Isle Royale.

Var. *catskillensis* is a northern form, ranging the Grand Traverse region through the upper peninsula, where it is the prevalent form.

Subgenus PLANOGYRA Morse.

Shell minute, orbicularly depressed, openly umbilicated, the spire flat, whorls bearing thin, sharp, spaced laminæ, parallel to growth striæ. Aperture rounded, lunar; lip simple.

PYRAMIDULA ASTERISCUS (Morse).

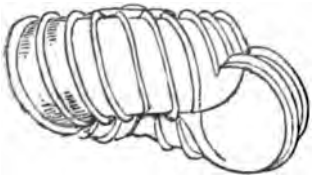


Fig. 84. *P. asteriscus.* ×26¾. (Morse.)

Shell widely umbilicated, orbicularly depressed, with from 25 to 30 delicate, thin, transparent laminæ parallel with growth lines, with wavy edges and inclined backwards; whorls 4, the upper one flattened, the last globose; suture deeply impressed; aperture subcircular; peristome simple, acute. Alt. ½; greater diam. 1½ mm.

Helix asteriscus, Morse, Proc. B. S. N. H., VI., 128, (1857).
Patula ————, W. G. Binney, Man. Am. Land Shells, 186, fig. 185, (1885).
Pyramidula ————, Walker, Rev. Moll. Fauna Mich., 16, (1894).

A northern species, which thus far has only been found at Charlevoix, Isle Royale and the Porcupine Mountains, Ontonagon county. Very minute, but very distinct in the position and character of the epidermal ribs, which follow the lines of growth, differing in this respect from *Zonitoides exigua.*

Genus HELICODISCUS Morse.

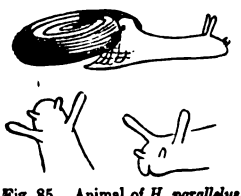


Fig. 85. Animal of *H. parallelus.* (Binney.)

Shell small, disk or coin-shaped, with flat spire and broad, shallow umbilicus; whorls numerous, convex and closely coiled, spirally striate or lirate, the last whorl having one or several pairs of tubercular teeth within, situated upon the inner surface of the outer whorl; aperture lunate; lip simple.

The shell lies perfectly flat upon the posterior end of the foot; the eye-peduncles standing nearly vertical; posterior end of the long and narrow foot conspicuously furrowed above, very short behind the mantle.

Fig. 86. Jaw of *H. parallelus.* (Binney.)

Jaw arcuate, striate, the striæ diverging somewhat from the median line; median projection inconspicuous.

Radula with centrals tricuspid, decidedly narrower than the laterals; laterals with large square basal-plates; marginals low and wide, tricuspid.

Fig. 87. Dentition of *H. parallelus.* (Binney.)

HELICODISCUS PARALLELUS (Say).

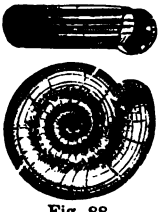


Fig. 88. *H. parallelus.* ×5.7 (Binney.)

Shell widely umbilicated, discoidal; whorls 4, equally visible above and below, with numerous, equidistant, parallel, raised, revolving lines; suture much impressed; aperture remote from axis, semi-lunate, narrow, not expanding; peristome acute, thin; within the aperture on the extreme circumference, are from one to three pairs of minute, conical, white teeth.

Alt. 1½; greater diam. 3½, lesser 3 mm.

Planorbis parallelus, Say, Proc. A. N. S. P., II., 164, (1821).
Helicodiscus lineatus, W. G. Binney, Man. Am. Land Shells, 75, fig. 37, (1885).
Helix lineata, Miles, Rep. Geol. Surv. Mich., 235, (1861).
Helicodiscus ———, Currier, Shell-bearing Moll. Mich., 5, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 6, (1881).
——— *lineatus*, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Common and of general distribution. Easily distinguished by its planorboid form and internal teeth.

Sub-family PUNCTINÆ Morse.

Jaw in numerous, distinct pieces, sometimes soldered together above, free and imbricated below. Marginal teeth quadrate.

KEY TO GENERA OF *PUNCTINÆ*.

I. Shell minute, subdiscoidal, openly umbilicated.....*Punctum.*
II. Shell pupæform, perforate.....*Sphyradium.*

Genus PUNCTUM Morse.

Shell minute, thin, subdiscoidal, but with convex spire, openly umbilicated. unicolored; whorls about 4, convex, the apical 1½ smooth, rather distinctly demarked from the following whorls, which have oblique striæ or irregular riblets and excessively fine spiral striæ; the last whorl cylindrical, not descending in front. Aperture lunate, rounded; lip simple, thin.

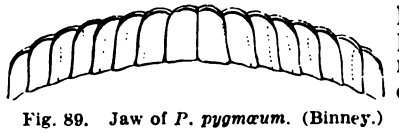


Fig. 89. Jaw of *P. pygmæum.* (Binney.)

Jaw arcuate or horse-shoe shaped, composed of numerous separate rhomboidal plates bound together by a thin transparent membrane, more or less overlapping, the outer imbricating over the inner plates; the median two or three plates slightly separated, not overlapping.

Radula long and narrow; teeth rather separated, not in the least overlapping; centrals tricuspid, with narrow basal plate; laterals with wider rhombic basal-plates and bicuspid; marginals not differentiated in any way from the laterals, but becoming lower with shorter cusps.

Fig. 90. Dentition of P. *pygmæum* (Binney.)

PUNCTUM PYGMÆUM (Draparnaud).

Fig. 91. *P. pygmæum.* (Binney.)

Shell very minute, broadly umbilicated, subglobose; reddish horn-color, shining, finely striate and with microscopic revolving lines; whorls 4, convex, gradually increasing; aperture subcircular, oblique; peristome simple, acute.

Alt. 1, greater diam. 1½ mm.

Helix pygmæa, Draparnaud, Tabl. Moll. France, 93, (1801).
Microphysa ———, W. G. Binney, Man. Am. Land Shells, 71, fig. 31, (1885).
Punctum pygmæum minutissimum, Walker, Rev. Moll. Fauna Mich., 16, (1894).

Generally distributed, but rarely found on account of its minute size.

Genus SPHYRADIUM Charpentier.

Shell elevated, pupæform. Jaw and radula as in *Punctum*.

Fig. 92. Dentition of *S. edentulum*. (Gwatkin.)

SPHYRADIUM EDENTULUM (Draparnaud).

Fig. 93. *S. edentulum.* ×11.6. (Binney.)

Shell minute, cylindrical, apex obtuse, finely and obliquely striate, light horn-color; whorls 5, moderately convex, suture deep; aperture circular; the peristome nearly continuous, simple, everted at its columellar margin, where it partially conceals a small umbilicus; aperture edentulous.

Alt. 1 3-5, diam. 4-5 mm.

Pupa edentula, Draparnaud, Hist. Moll., 52, pl. III., fig. 28-9, (1805).
Vertigo simplex, W. G. Binney, Man. Am. Land Shells, 191, fig. 195, (1885).
——— ———, Miles, Rep. Geol. Surv. Mich., 236, (1861).
——— ———, Currier, Shell-bearing Moll. Mich., 5, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 7, (1881).
Pupa edentula simplex, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Apparently of general distribution, though not abundant. Characterized by its cylindrical form, striate surface and edentulous aperture.

Family PHILOMYCIDÆ.

Animal limaciform, mantle covering the whole body; jaw with or without anterior ribs and a median projection to cutting edge; lingual membrane of *Helicidæ*; no shell.

KEY TO GENERA OF *PHILOMYCIDÆ*.

I. Jaw smooth..... *Philomycus.*
II. Jaw ribbed..... *Pallifera.*

Genus **PHILOMYCUS** (Rafinesque) Ferussac.

Animal limaciform. Body somewhat flattened, terminating obtusely or in a somewhat truncated form, obtuse anteriorly. Back convex, more flat, when fully extended. Integuments with irregular vermiform glands, anastomosing with each other and having a general longitudinal direction. Mantle covering the whole body. Foot expanded at its margin and visible beyond the edges of the mantle. No locomotive disk. Respiratory orifice near the head, some way to the rear of the right eye-peduncle. Anal orifice contiguous to and a little above and in advance of the pulmonary orifice. Orifice of organs of generation behind and below the right eye-peduncle. No caudal mucus pore. No external or internal shell.

Fig. 94. Jaw of *P. carolinensis.* (Binney.)

Jaw horn-colored, arcuate, with irregular concave margin, bearing a blunt slightly projecting beak; terminations blunt; the anterior surface convex, without a decided median carina, anterior surface smooth.

Lingual membrane arranged as usual in *Helicidæ*, long and narrow; centrals with a long narrow base of attachment, widening toward the lower margin, which is excavated, unicuspid; laterals like the centrals, but asymmetrical; marginals quadrate, longer than wide, obtusely bicuspid.

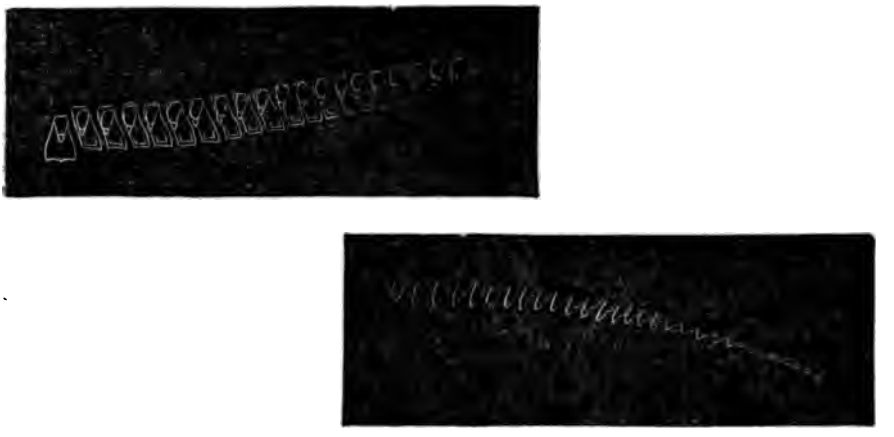


Fig. 95. Dentition of *P. carolinensis.* (Binney.)

PHILOMYCUS CAROLINENSIS (Bosc).

Body elongated, subcylindrical, flattened towards its posterior extremity,

Fig. 96. *P. carolinensis.* (Binney.)

which is obtuse; eye-peduncles short, stout, terminating in a bulb; tentacles immediately below, very short, nearly conical; mantle fleshy, covering the whole body, surface longitudinally rugose; color above whitish or yellowish-white, varigated with clouds and spots of brownish and blackish, so arranged as to form three ill-defined longitudinal bands, inferior margin white or yellowish; foot whitish, extending a little beyond the mantle posteriorly, show-

ing a whitish, flattened border. Respiratory orifice large, on the right side, one-fourth of an inch behind the origin of the eye-peduncle. Length 3-4 inches.

Limax *carolinensis*, Bosc., Vers de Buffon de Deterville, 80, pl. III, fig. 1.

Tebennophorns ————, W. G. Binney, Man. Am. Land Shells, 241, fig. 260, (1885).

———— ————. Walker, Rev. Moll. Fauna Mich., 16, (1894).

Generally distributed in the lower peninsula.

Genus **PALLIFERA** Morse.

Jaw stout, arcuate, ends but little attenuated, blunt; anterior surface with stout, separate ribs. Other characteristics as in *Philomycus*.

Fig. 97. Jaw of *P. dorsalis*. (Binney.)

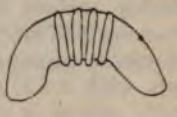


Fig. 98. Jaw of *P. hemphilli*. (Binney.)

Fig. 99. Dentition of *P. dorsalis*. (Binney.)

KEY TO THE SPECIES OF *PALLIFERA*.

I. Light colored. Jaw with nine ribs..... *dorsalis*.
II. Black. Jaw with five ribs, concentrated on the middle third..... *hemphilli*.

PALLIFERA DORSALIS (Binney).

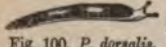


Fig. 100. *P. dorsalis*. (Binney.)

Color of upper surface ashy, with a shade of blue. An interrupted black line extending down the centre of the back; eye peduncles black, about one-eighth of the length of the body; tentacles blackish, very short. Body cylindrical and narrow, terminating posteriorly in an acute point; base of foot white, very narrow, its separation from the body not well defined. Upper surface covered with elongated and slightly prominent glandular projections, the furrows between indistinct. Respiratory orifice very minute, situated on the right side, about one-eighth of an inch behind the insertion of the eye-peduncle. The mantle is closely connected with the body.

Length, 18 mm.

Philomycus *dorsalis*, Binney, Bost. Jour. Nat. Hist., IV., 174 (1842).

Tebennophorus ———, W. G. Binney, Man. Am. Land Shells, 244, fig. 261, (1885).

A species of the Northern region found only as yet in Ontonagon and Marquette counties, and at Olivet, Eaton county. Distinguished by its slender form, light color and strongly ribbed jaw.

PALLIFERA HEMPHILLI (W. G. Binney).

Fig. 101.
P. hemphilli. (Binney.)

Animal long, narrow, cylindrical, with a pointed tail. Black. Jaw strongly arched with a median projection and four or five ribs, all concentrated on the middle third, the outer thirds being ribless. Length (in alcohol) 25 mm.

Tebennophorus hemphilli, W. G. Binney, Man. Am. Land Shells, 247, (1885).

Originally described from North Carolina and Georgia, this species has recently been taken in Ontonagon county and at Ann Arbor. Easily distinguished from *P. dorsalis* by its color and the peculiar arrangement of the ribs on the jaw.

II. HETERURETHRA.

Superfamily ELASMOGNATHA.

Family **SUCCINEIDÆ.**

Tentacles but little developed or wanting. Jaw surmounted by an accessory quadrangular plate. Central tooth of the lingual membrane tricuspid, of the same size as the laterals, which are tricuspid or bicuspid, of the type of the *Helicidæ*. Marginal teeth quadrate, with narrow base, multicuspid reflection, serrate by the splitting of the inner cusp into numerous denticles. Shell external or internal, very thin, transparent, spiral.

Genus **SUCCINEA** (Draparnaud).

Shell imperforate, thin, ovate or oblong; aperture large, obliquely oval. columella simple, acute; peristome simple, straight.

Fig. 102.
Animal of *Succinea.*
(Binney.)

Animal heliciform, thick and blunt before, short and pointed behind; mantle central, simple, protected by a shell which does not conceal the whole retracted animal; respiratory and anal orifices on the right of the mantle edge under the peristome; generative orifice behind the right eye-depuncle; no caudal mucus pore.

Jaw with an upper, quadrangular, accessory plate; strongly arched, the end acuminated or blunt, with a median projection to the cutting margin, ribbed or smooth.

Fig. 103. Jaw of *S. retusa.*

Fig. 104. Jaw of *S. ovalis.*

Fig. 105. Jaw of *S. avara.*

Radula with centrals tricuspid; laterals bicuspid or tricuspid; marginals short, serriform; the centre of the lower edge of the basal plates of the centrals and inner lower lateral angle of the basal plates of the laterals and marginals cut away. The reflection of the teeth is small in proportion to the size of the basal plates.

Fig. 106. Dentition of *S. retusa* (Binney.)

KEY TO THE SPECIES OF *SUCCINEA.*

I. Spire very small, aperture very large, more than one-half of entire length of shell.
   a. Body whorl large, expanded, aperture broadly oval.....*obliqua.*
   aa. Body whorl compressed, elongate, aperture elongated.....*retusa.*
II. Spire prominent, acute, whorls very convex, suture deep, aperture rounded at both extremities, ovate, hirsute when young.....*avara.*

SUCCINEA RETUSA Lea.

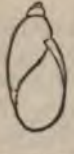


Fig. 107. *S. retusa.* (Lea.)

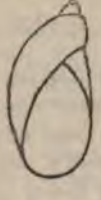


Fig. 108. *S. calumetensis.* ×2. (Calkins.)

Fig. 109. *S. retusa.* (Binney.)

Shell ovate, somewhat conic, very thin, pellucid, light yellow or grayish, horn-color; shining, very minutely striate; whorls 3, the last compressed and elongated; spire short but acute; suture impressed; aperture elongated, more or less patulous, expanding anteriorly.

Alt. 15, of aperture, 10 mm.

Succinea retusa, Lea, Trans. Am. Phil. Soc., V., 117, pl. XIX., fig. 86, (1837).

——— *ovalis*, W. G. Binney, Man. Am. Land Shells, 338, fig. 368, (1885).

Succinea ovalis, Sager, Doc. H. Rep. Mich., 1839, 420, separate, p. 14.
——— ———, Miles, Rep. Geol. Surv Mich., 236, (1861).
——— ———, Currier, Shell-bearing Moll. Mich., 4, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 5, (1881).
——— ———, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Fig. 110. *S. retusa magister.*

Fig. 111. *S. retusa decampii.* ×2.

Fig. 112. *S. retusa peoriensis.* ×2

Var. **MAGISTER** Pilsbry.

"Distinguished from *S. retusa* Lea, by its larger size, less developed spire and larger aperture."

Alt. 18, greater diam. 9½-10, length of aperture 13-14 mm.

Succinea retusa magister, Pilsbry, Naut. XII., 103, (1899).

Var. **DECAMPII** Tryon.

Ovate-conic, translucent, finely striate, polished; spire short, acute; suture moderately impressed; whorls 3, very oblique, narrow, flattened; aperture narrow, ovate; columella slightly incurved; yellowish-ash color, edge of aperture black.

Alt. 10, diam. 5 mm.

Succinea decampii, Tryon, Am. Jour. Con., II., 237, pl. II., fig. 23, (1866).
——— *decampi*, Currier, Shell-bearing Moll. Mich., 4, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 5, (1881).
——— *ovalis decampii*, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Var. **PEORIENSIS** Wolf.

Ovate, spire obtuse, more elevated than in the typical form; body-whorl less elongated and more inflated; aperture nearly oval, somewhat angular above and regularly rounded below, scarcely patulous.

Alt. 10, diam. 6 mm.

Succinea peoriensis (Wolf), Walker, Naut. VII., 127, (1894).
——— *peonensis*, DeCamp, Shell-bearing Moll. Mich., 5, (1881).
——— *ovalis peoriensis*, Walker, Rev. Moll. Fauna Mich., 17, (1894).

This species usually known as *S. ovalis*, Gould *non* Say, is one of the most abundant and variable species found in the state. The variation is so great and the characteristics afforded by the shells alone are so slight and elusive, that until the anatomical details have been worked out, which, perhaps, may afford more reliable specific features, it is questionable whether any satisfactory arrangement can be made. There are several well marked varieties found in Michigan, which might be satisfactorily described from selected examples, but, in any considerable number of specimens, they seem to intergrade almost without limit. Under these circumstances it does not seem wise to attempt to do more than to define the varietal forms already described, it being understood, of course, that intermediate forms of all grades of relationship are liable to be met with. What may perhaps be

considered the typical form (*ovalis* Gld.), is that represented by Fig. 109, copied from Binney, and is characterized by its very short, rather blunt spire, elongated body whorl, and patulous aperture, expanding anteriorly.

Pilsbry's var. *magister* is distinguished by its large size, less developed spire and larger aperture. It has been cited from Michigan by Pilsbry, but I have never seen any specimens from this state that answer the description. The figure is from the type in the collection of the Philadelphia Academy. Tryon's var. *decampii* is well marked typically by its elongated, compressed form, peculiar color and black-edged lip. But the color and form are not always correlated. Specimens similar to *peoriensis* in form, and to *decampii* in color are not uncommon. In form this variety, typically, is similar to a well marked race of larger size, which is quite characteristic of the northern part of the state, and which has been erroneously quoted as *S. higginsi* Bld. In the western part of the state a much larger form is found, with a somewhat more elongated spire than in the typical form, which seems to be nearer Lea's *retusa* (fig. 107). Calkins' *S. calumetensis*, (fig. 108), is a doubtful form scarcely, if at all, different from the *ovalis* of Gould.

A very large form from East Saginaw, collected by the late Dr. G. A. Lathrop, seems to bear the same relation to the elongated northern form referred to in connection with var. *decampii* that typical *retusa* apparently does to the *ovalis* of Gould. The elucidation of the inter-relationship of these puzzling forms requires careful anatomical comparison and is one of the most important problems in regard to our terrestrial mollusca, which still remains to be solved.

SUCCINEA OVALIS Say.

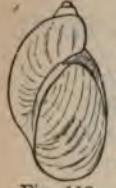


Fig. 113. *S. ovalis.* (Binney.)

Shell ovate, pale green, yellowish-green, amber-colored or cinereous, thin and fragile, pellucid; shining, minutely wrinkled or striated; whorls 3, the last very large and much expanded, and more or less oblique; spire very small, not prominent nor pointed; suture distinct, impressed; aperture oval, large and expanded. columella thin, sharp, narrowed; peristome thin.

Alt. 18 to 25 mm.

Succinea ovalis, Say, Jour. A. N. S. P., I., 15, (1817).
——— *obliqua*, W. G. Binney, Man. Am. Land Shells, 341, fig. 371, (1885).
——— *campestris*, Sager, Doc. H. Rep. Mich., 1839, 420, separate, p. 14.
——— ———, Miles, Rep. Geol. Surv. Mich., 236, (1861).
——— *obliqua*, Miles, Rep. Geol. Surv. Mich., 236, (1861).
——— ———, Currier, Shell-bearing Moll. Mich., 4, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 5, (1881).
——— ———, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Although not as abundant as either *retusa* or *avara*, this species has a general distribution in the lower peninsula. It has not yet been reported from the upper peninsula except on Isle Royale. Occasional specimens are very close to the eastern form known as *S. totteniana* Lea, both in color and form.

The accepted nomenclature of this species (*S. obliqua*, Say), has been erroneous for many years. Say's original description of *S. ovalis* in 1817 has priority over his later use of *obliqua* for another form of the same species. Dr. Amos Binney attempted to apply *ovalis* to the species now known as

S. retusa Lea, and to retain the name of *obliqua* for this form, but such usage cannot be supported by the recognized law of priority in nomenclature.

SUCCINEA AVARA Say.

Fig. 114. *S. avara*, (Binney.)

Shell rather small, very thin and fragile, yellowish horn-color, amber-colored or greenish; shining, minutely hirsute when young; whorls 3, very convex, separated by a deep suture; last whorl large, not much expanded; spire very prominent, acute; aperture ovate, rounded at both extremities, about half as long as the shell. Alt. 6-10 mm.

Succinea avara, Say, Long's Exped., II., 260, pl. XV., fig. 6, (1822).
——— ———, W. G. Binney, Man. Am. Land Shells, 339, fig. 369, (1885).
——— ———, Miles, Rep. Geol. Surv. Mich., (1861).
——— ———, Currier, Shell-bearing Moll. Mich., 4, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 5, (1881).
——— ———, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Var. **ALBA** Cockerell.

Shell white or greenish white.
Succinea avara alba, Cockerell, Naut. VII., 43, (1893).

Var. **MAJOR** W. G. Binney.

Larger, Alt. 10-14 mm.
Succinea avara major, W. G. Binney, Proc. A. N. S. P., 1858, 199.

Var. **VERMETA** Say.

Succinea vermeta, Say, New Harm. Diss., II., 230, (1829).
——— ———, Miles, Rep. Geol. Surv. Mich., 236, (1861).
——— ———, Currier, Shell-bearing Moll. Mich., 4, (1865).
——— ———, DeCamp, Shell-bearing Moll. Mich., 5, (1881).

Suture very deeply impressed, almost scalariform.

Very abundant and of general distribution. The varieties *major* and *vermeta* occur quite frequently associated with the type and intergrade completely with it and with each other. The var. *alba* is more rare. Two or even all of the varietal characteristics may be not uncommonly found exemplified in a single individual.

III. ORTHURETHRA.

KEY TO THE FAMILIES OF *ORTHURETHRA*.

I. Shell elongated, subcylindrical.
  a. Columella truncated ..... *Cochlicopidæ.*
  aa. Columella continuous with the basal lip ..... *Pupillidæ.*
II. Shell conical, heliciform.
  a. Aperture with parietal lamellæ ..... *Pupillidæ.*
  aa. No apertural lamellæ ..... *Valloniidæ.*

Family PUPILLIDÆ.

Jaw smooth or finely striate, lower margin with or without a projection, sometimes reinforced with a superior arched appendage, like forming a double jaw, and to be compared to the accessory plate of the jaw of *Succinea*; lingual membrane similar to that of the *Helicidæ*; central tooth of same form and usually of same size as the laterals, laterals tricuspid; marginal teeth quadrate, wide, low denticulated.

Shell generally multispiral, elongated, conic or cylindrical; aperture small, often narrowed by internal teeth or lamellæ.

"As it is well known, most of the folds or teeth in the apertures of *Pupa* (*Pupilla*) have definite positions, and the principal ones are homologous throughout the group.

We therefore offer below a revised terminology of the apertural armature applicable to all *Pupidæ* (*Pupillidæ*), and requiring no especial reference to a key, as the terms are to a large extent sub-explanatory.

The plan is to call all projections upon the parietal wall and columella "lamellæ," those within the basal and outer walls of the aperture "plicæ" or folds. The nomenclature of particular folds is then as follows:

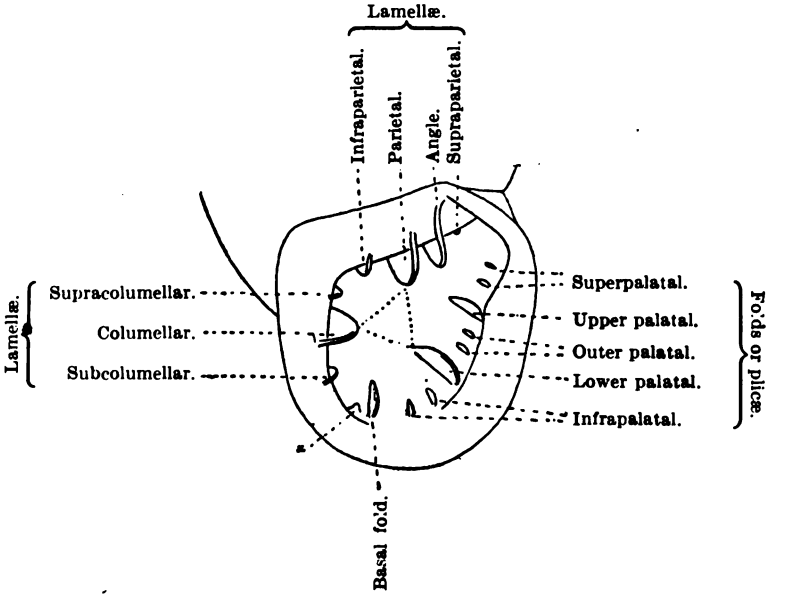


Fig. 115. Apertural lamellæ and folds of *Pupillidæ*. (Pilsbry.)

"But few *Pupidæ* (*Pupillidæ*), have all the folds named, and some of them are rarely present in American species. The infra-parietal, supra and subcolumellar lamellæ and the infra-, inter- and supra-palatal folds are 'secondary' in nearly all groups, and often vary in the species. The others are more constant, and vary but little in position when developed. The parietal and columellar lamellæ and the lower parietal fold, are at the angles of a nearly equilateral triangle, when the said palatal is not deeply immersed."*

* Pilsbry, Proc. A. N. S. P. 1900, 582.

KEY TO THE GENERA OF *PUPILLIDÆ*.

I. Shell globose, conic or depressed, heliciform; aperture with entering lamellæ..... *Strobilops.*
II. Shell elongated, pupiform.
a. Lip simple, surface costate..... *Acanthinula.*
b. Lip thickened, surface smooth or finely striate.
c. Aperture with outer lip regularly rounded, lower tentacles present.
d. Aperture edentate.
e. Spire acuminate, lip thickened, flatly reflected..... *Pupoides.*
ee. Spire cylindrical, obtuse, lip sharp, expanded..... *Pupilla.*
dd. Aperture dentate, lip more or less expanded.
e. No tooth on the columella..... *Pupilla.*
ee. One or more teeth on the columella..... *Bifidaria.*
cc. Aperture with outer lip more or less contracted above the middle, usually strongly indentated, lower tentacles obsolete.... *Vertigo.*

Genus **STROBILOPS** Pilsbry.

Fig. 116. Animal of *Strobilops.* (Binney.)

Shell umbilicated, globose, conic or depressed, obliquely and coarsely striated, smoother below; whorls 5 or 6, the last globose; aperture lunately rounded; peristome thickened, reflected; the parietal wall and base of the last whorl, each with two or more entering, revolving laminæ.

Animal quite small in comparison to the size of the shell; eye-peduncles thick, bulbous; eyes very large.

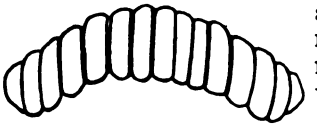


Fig. 117. Jaw of *Strobilops.* (Binney)

Jaw low, wide, slightly arcuate, ends scarcely attenuated, blunt; cutting margin without median projection; anterior surface with crowded ribs, denticulating either margin and more developed on the centre of the jaw.

Lingual membrane as usual in *Helicidæ*, long and narrow, with 78 rows of 13- 1- 13 teeth with 5 perfect laterals.

Fig. 118. Dentition of *Strobilops.* (Binney.)

KEY TO THE SPECIES OF *STROBILOPS.**

I. Spire elevated, conoidal, internal lamellæ on floor of body whorl 2 to 4, short ..... *labyrinthica.*
II. Spire globosely elevated, internal lamellæ on floor and adjacent side wall of body whorl, 6 or more.
a. Six long lamellæ; umbilicus a perforation merely..... *virgo.*
aa. About 8 short lamellæ arranged in a curved radial series, umbilicus wider and deep..... *affinis.*

* Adapted from Pilsbry, Naut. VII, 56.

STROBILOPS LABYRINTHICA (Say).

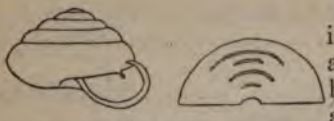


Fig. 119. *S. labyrinthica.* ×8.4

Shell umbilicated, elevated conoidal, brownish horn-color, with strong ribs above, below almost smooth; spire obtuse; whorls wider than high, regularly increasing in size from apex to aperture; body-whorl obtusely angulated at the periphery, flattened below, impressed around the narrow umbilicus; aperture rounded above, basal margin flattened, peristome narrowly reflected, thickened; parietal wall with three revolving, deeply entering parallel lamellæ, the central further within the aperture and less developed, one conspicuously emerging from the aperture; two to four short, internal lamellæ on base of body whorl.

Alt. 1¾, greater diam. 2¼ mm.

Helix labyrinthica, Say, Jour. A. N. S. P., I., 124, (1817).
Strobila ————, W. G. Binney, Man. Am. Land Shells, 264, fig. 281, (1885).
Helix ————, Miles, Rep. Geol. Surv. Mich., 235, (1861).
Strobila ————, Currier, Shell-bearing Moll. Mich., 4, (1868).
—— ————, DeCamp, Shell-bearing Moll. Mich., 6, (1881).
Strobilops ————, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Apparently rare in this state. Bay, Saginaw, Kent, Kalamazoo and Berrien counties are the only localities reported.

This species is easily to be distinguished from both *virgo* and *affinis*, not only by the constant difference in the number and situation of the internal lamellæ, but by the depressed form, more conical spire, stronger ribs and flattened base; viewed from above the whorls are noticeably wider than in either of the other species and the peripheral angle is much stronger. Its general appearance is that of a lower, wider shell than either of the other species.

STROBILOPS VIRGO (Pilsbry).

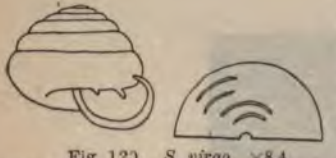


Fig. 120. *S. virgo.* ×8.4

Shell umbilicated, globosely elevated; white or pale brownish color; finely and closely ribbed above, ribs sub-obsolete on the base; spire high; dome-shaped; whorls 5½, narrow, about as high as wide, body whorl somewhat angled at the periphery, rounded below, impressed around the umbilicus which is a mere perforation; aperture lunately rounded; peristome narrow, thickened, reflected; two parietal folds conspicuously emerging; 6 long lamellæ on the base and outer wall of the body whorl.

Alt. 2, greater diam. 2¼ mm.

Strobila labyrinthica virgo, Pilsbry, Naut. VI., 94, 1892.
Strobilops virgo, Pilsbry, Naut. VII., 56, (1893).
———— ————, Walker, Rev. Moll. Fauna Mich., 17, (1894).

The only species yet reported from the northern part of the state, where it is quite abundant. South of Iosco county, the only localities reported are in Oakland, Saginaw and Kalamazoo counties.

Aside from the peculiar arrangement of both the internal and parietal lamellæ, *virgo* is easily separated from *labyrinthica* by its rounded dome-shaped spire, finer ribs, rounder aperture, and more convex base and less accentuated peripheral angle.

From *affinis*, it differs in size, narrow umbilicus, more rounded spire and more rounded base; the arrangement of the apertural lamellæ is also quite different. Only four of the lamellæ appear on the base, the others being at and above the periphery.

STROBILOPES AFFINIS Pilsbry.

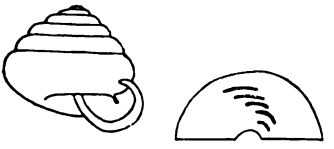


Fig. 121. *S. affinis.* ×8.4.

Shell umbilicated; obtusely elevated; dark brown; finely and closely ribbed above, ribs lighter below; spire obtusely elevated; whorls 5½, rather narrow, higher than wide, body whorl obtusely angled at the periphery, somewhat flattened, but rounded below, impressed around the umbilicus, which is round and deep; aperture lunately rounded; peristome thickened, narrowly reflected; about 8 short lamellæ arranged in a forwardly curved radial series from the axis across the base and up the outer wall of the body whorl.

Alt. 2½, greater diam. 2⅞ mm.

Strobilops affinis, Pilsbry, Naut. VII., 56, (1893).

Apparently of general distribution in the southern part of the state, but as yet has not been reported north of the Saginaw-Grand valley.

Its essential characteristics as compared with the other species of the genus, have already been pointed out. But it may be added, that while it is uniformly larger than either of the others, in contour it is intermediate between them, although, as a whole, nearer to *virgo* than *labyrinthica*. Compared with *labyrinthica*, the spire is more obtusely elevated, the whorls are narrower, the base more rounded, the aperture is rounded below and the peripheral angle is less pronounced. Compared with *virgo* the spire is not so globosely elevated; but is higher in proportion to the body whorl; whorls are rather wider, the ribs stronger, the base more flattened; the peripheral angle more marked; the aperture about the same in both. The arrangement of the lamellæ is very characteristic five only appear on the base, the others being at and above the periphery.

Genus **ACANTHINULA** Beck.

Shell minute, pyramidal or globosely turbinate, thin, brown, minutely umbilicated. Epidermis raised into lamellæ crossing the whorls. Aperture subvertical or subcircular; the lip acute, expanded toward the columellar insertion, the margins remote.

Section **ZOÖGENITES** Morse.

Shell globosely turbinate, perforate, ornamented with oblique, cuticular lamellæ.

Fig. 122. Animal of *A. harpa*. (Binney.)

Animal with the foot-edges prominently crenulated; labial lobes large; lower tentacles nearly obsolete. Genitalia unknown.

Fig. 123. Jaw of *A. harpa*. (Binney.)

Jaw arched, with numerous wide, subobsolete ribs. Radula with formula 11, 6, 1, 6, 11. Middle teeth tricuspid, the mesocone not reaching edge of square basal plate; laterals bicuspid; marginals wide with many irregular cusps.

Fig. 124. Dentition of *A. harpa*. (Binney.)

ACANTHINULA HARPA (Say).

Fig. 125. *A. harpa*. (Binney.) ×6.

Shell subperforate, ovately conic, pellucid, very thin, irregular striate, light horn color; spire conical, rather obtuse; whorls four, convex, the upper ones smooth, the last two with prominent distant, thin, colorless ribs, the last whorl rounded, somewhat longer than the spire; aperture lunately oval; peristome simple, acute.

Alt. 3½, greater diam. 2 mm.

Helix harpa, Say, Long's Exped., II., 256, pl. XV., fig. 1, (1824).
Acanthinula harpa, W. G. Binney, Man. Am. Land Shells, 185, fig. 183, (1885).
——— ———, Walker, Rev. Moll. Fauna Mich., 16, (1894).

A northern species. The Porcupine mountains, Ontonagon county, and Isle Royale, in the Upper Peninsula, and Charlevoix, Petoskey and Beulah, Benzie county, in the Grand Traverse region are the localities thus far reported. Easily distinguished by its elevated shape and prominent ribs.

Genus PUPOIDES Pfeiffer.

Shell rimate, cylindrically ovate, apex rather obtuse, rather smooth, shining, pellucid; whorls 6-7, rather convex, aperture semi-ovate, edentate; peristome thickened, reflected, its external margin decidedly arcuate.

Animal as in *Pupilla*.

Fig. 126. Jaw of *P. marginatus*.

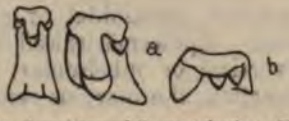


Fig. 127. Dentition of *P. marginatus*. (Binney.)

PUPOIDES MARGINATUS (Say).

Fig. 128. *P. marginatus*. (Binney.) ×4.

Shell fusiform, regularly diminishing in size from the body-whorl to the apex, smooth; brownish horn-color; whorls 6 very convex, very lightly striate; suture well impressed; aperture lateral, rounded oval; peristome white, rather broadly reflected, strongly curved above; umbilicus perforated.

Alt. 5½, diam. 2-2½ mm.

Cyclostoma marginata, Say, Jour. A. N. S. P., II., 172, (1821).
Pupa fallax W. G. Binney, Man. Am. Land Shells, 324, fig. 351, (1885).

Bulimus marginatus, Miles, Rep. Geol. Surv. Mich., 236, (1861).
Pupa fallax, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Not a common species. Reported from Berrien, Kent, Genesee, Monroe, and Washtenaw counties.

Genus **BIFIDARIA** Sterki.

Shell small, umbilicus perforate, cylindrical, turriculate, conic or ovoid; surface smooth, polished or finely striate or, rarely, finely ribbed; aperture lateral, oval or sub-orbicular; contracted by one or more teeth on the parietal wall and inner margin of the lip and columella; peristome expanded or reflected; parietal lamella large and more or less distinctly complex, formed by the fusing of the parietal and supraparietal lamellæ; the columellar lamella also generally somewhat complex; the typical inferior and superior palatal lamellæ are generally present and as a rule deep seated, never reaching the margin.

Animal, jaw and dentition as in *Pupilla*.

Fig. 129. Animal of *B. tappaniana*. (Binney.)

Fig. 130. Jaw of *B. tappaniana*. (Binney.)

Fig. 131. Dentition of *B. tappaniana*. (Binney.)

KEY TO THE SECTIONS OF *BIFIDARIA*.*

I. Parietal and angle lamellæ very short, small and tuberculiform; no palatal folds; shell cylindrical..... *Privatula.*
II. Parietal and angle lamellæ elongate, more or less united, either by a callous ridge, or so extensively as to appear like a single sinuous, or emarginate lamella..... *Albinula.*
III. Parietal lamella simple; no angle lamella; parietals normal or increased by accessory denticles, often standing on a callous ridge.. *Vertigopsis.*

KEY TO THE SPECIES OF *BIFIDARIA*.

I. Base of shell between umbilicus and margin compressed, forming a keel.
  a. Shell cylindrical, apex obtuse, length more than 4⅔ mm..... *armifera.*
  aa. Shell sub-conical, length 3 mm..... *contracta.*
II. Base of shell rounded.
  a. Aperture multidentate, labial teeth on a ridge of callus, contracting the aperture.
    b. Shell obtusely conical, last whorl widest, parietal and inferior palatal teeth straight..... *tappaniana.*

* Adapted from Pilsbry, Proc. A. N. S. P., 1900, 593.

bb. Shell cylindrical, last whorl not wider than the penultimate, parietal and inferior palatal teeth curved.....*pentodon.*
aa. Aperture not thickened within, no labial teeth.....*corticaria.*

Section **ALBINULA** Sterki.

Throat nearly closed by teeth. Shell oblong or conic, rather wide; parietal and calumellar lamellæ long and tortuous, the latter more or less vertical; palatal folds several, situated on a ridge.

BIFIDARIA ARMIFERA (Say).

Fig. 132. *B. armifera.* (Binney.) ×8.6

Shell cylindrical, smooth; whorls 6-7, convex, apex rather obtuse; suture impressed; peristome white, thin, subreflected, forming the whole outline of the aperture, its extremities connected by a callus deposit on parietal wall; aperture oval, deep, cup-shaped, and narrowing toward the throat; parietal lamella large, irregular, with one or two sharp projecting points, and is sometimes bifid; columellar lamella thick, massive and situated deep in the throat; palatal folds two, situated on the base of the aperture; base of shell from umbilicus to margin compressed, forming a short and obtuse keel; umbilicus a little expanded and slightly perforate.

Alt. 4⅞, diam. 2⅝ mm.

Pupa *armifera*, Say, Jour. A. N. S. P., II., 162, (1821).
——— ———, W. G. Binney, Man. Am. Land Shells, 325, fig. 352, (1885).
——— ———, Miles, Rep. Geol. Surv. Mich., 236, (1861).
Leucochilla ———, Currier, Shell-bearing Moll. Mich., 6, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 7, (1881).
Pupa ———, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Generally distributed in the southern part of the state. Easily distinguished from *B. contracta*, which is the only species resembling it in the form of the aperture, by its greater size and the arrangement of the apertural lamellæ.

BIFIDARIA CONTRACTA (Say).

Fig. 133. *B. contracta.* (Binney.)

Shell subconical, white, whorls 5-6, very convex, diminishing regularly from the last whorl to the apex; suture well impressed; peristome white, somewhat reflected, its extremities connected by a raised testaceous fold making the margin of the aperture entire; aperture rather triangular, expanded above and diminishing regularly into a very narrow throat; lamellæ four; parietal, large, coarse and irregular, projecting into the aperture; superior palatal fold not large, tuberculous and placed near the margin of the peristome, the inferior palatal large, deeply seated near the base, the columellar lamella large and massive and deeply seated

in the throat; umbilicus minutely perforate; base of shell sharply keeled between the umbilicus and margin; last whorl impressed behind the peristome.

Alt. 3, diam. 1¾ mm.

Pupa *contracta*, Say, Jour. A. N. S. P., II., 374, (1822).
—— ————, W. G. Binney, Man. Am. Land Shells, 327, fig. 353½, (1885).
—— ————, Miles, Rep. Geol. Surv. Mich., 236, (1881).
Leucochilla ————, Currier, Shell-bearing Moll. Mich., (1868).
———— ————, DeCamp, Shell-bearing Moll. Mich., 7, (1881).
Pupa ————, Walker, Rev. Moll. Fauna Mich., 17, (1894).

The most common species of the genus and of general distribution over the entire state.

Section **PRIVATULA** Sterki.

Parietal and angle lamellæ very small, short and tuberculiform; no palatal folds; shell cylindrical.

BIFIDARIA CORTICARIA (Say).

Fig. 134. *B. corticaria*. (Binney.)

Shell whitish, shining, cylindrical, apex obtuse; whorls 5-6, convex; suture well impressed; aperture two-thirds as wide as the last whorl, sub-orbicular, with a single tooth (sometimes two) on the parietal wall, near the centre and a tooth-like enlargement near the umbilical termination of the peristome, which is white, reflected; umbilicus very minutely perforated.

Alt. 2½, diam. 1 mm.

Odostomia *corticaria*, Say, Nich. Encycl. IV, pl. IV, fig. 5, (1817).
Pupa ————, W. G. Binney, Man. Am. Land Shells, 330, fig. 355, (1885).
Leucochilla ————, DeCamp, Shell-bearing Moll. Mich., 7, (1881).
Pupa ————, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Apparently of general distribution over the entire state. Differs from all the other species of the genus in the lack of labial teeth.

Subgenus **VERTIGOPSIS** (Ckll.) Sterki.

Parietal lamella simple; no angle lamella; palatals normal or increased by accessory denticles, often standing on a callous ridge.

BIFIDARIA PENTODON (Say).

Shell ovate, sub-cylindrical, much elongated; spermaceti white; whorls 5, convex, smooth, gradually diminishing to an obtuse apex; suture deeply impressed; aperture sub-triangular, the transverse margin straight and slightly oblique, columella nearly straight; peristome somewhat expanded, thickened within by a callus deposit bearing the lamellæ; lamellæ five to nine, the parietal and inferior palatal curved to the left; perforate.

Alt. 1⅔ diam., ⅝ mm.

Vertigo pentodon, Say, Jour. A. N. S. P., II., 376, (1821).
Pupa *curvidens*, Gould, Invert. Mass., 189, fig. 120, (1841).
—— *pentodon*, W. G. Binney, Man. Am. Land Shells, 323, fig. 347, (1885).
—— *curvidens*, Walker, Rev. Moll. Fauna Mich., 17, (1894).

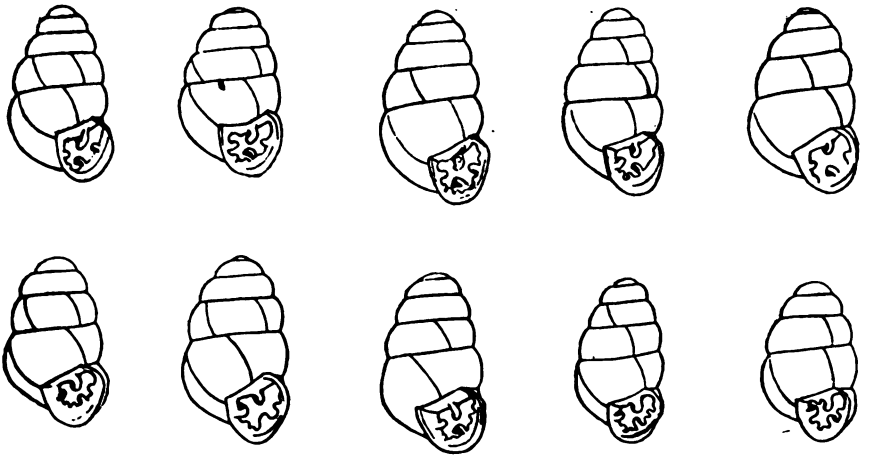


Fig. 135. *B. pentodon.* (P. & V.) ×13.8.

Not abundant, but apparently of general distribution through the state. Closely related to *B. tappaniana*, from which it is distinguished by its smaller size, more cylindrical outline, and curved parietal and inferior palatal folds. This species has been commonly known as *B. curvidens* Gld., But Dr. Pilsbry has recently shown that this is the *B. pentodon* of Say and not the species usually so called.

BIFIDARIA TAPPANIANA (C. B. Adams).

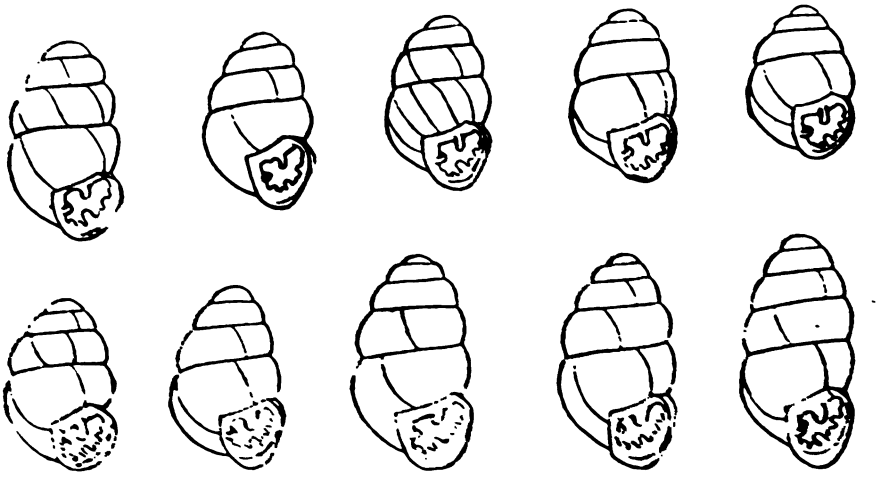


Fig. 136. *B. tappaniana.* P. & V. ×13.8.

Shell sub-perforate, elongate, ovate, of a spermaceti or whitish horn-color; whorls 5, well rounded and separated by a deep suture; apex rather acute; aperture oblique, nearly semi-circular; peristome sharp and somewhat expanded, but not reflected; the inner margin thickened by a ridge of white callus, on which the palatals are situated; lamellæ 5 to 10, of

the parietal is the largest, the columellar next and the inferior palatal third in size; parietal and inferior palatal straight.

Alt. 2, diam. 1 mm.

Pupa tappaniana, C. B. Adams, Thomp. Hist. of Vt., 158, (1842).
—— *pentodon*, W. G. Binney, Man. Am. Land Shells, 323, fig. 348, (1885).
—— ——, Miles, Rep. Geol. Surv. Mich., 236, (1861).
Pupilla ——, Currier, Shell-bearing Moll. Mich., 6, (1868).
—— ——, DeCamp, Shell-bearing Moll. Mich., 7, (1881).
Pupa ——, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Distribution probably the same as that of *B. pentodon*. This species and *pentodon* are distinguished by the ridge of callus within the lip on which the lamellæ are situated. Heretofore usually known as *B. pentodon* Say. But Say's species is that commonly called *B. curvidens* Gld.

Genus **PUPILLA** Leach.

Shell deeply rimate or perforate, cylindrically shortened, apex extended into an obtuse cone, horn-colored, smooth; whorls 5-9; aperture rounded with few or no folds; peristome somewhat expanded.

Fig. 137. Animal of *P. muscorum*. (Binney.)

Animal heliciform, small, short, blunt before, tapering behind; mantle posterior, thin, protected by a shell; respiratory and anal orifices on the right side of the mantle, under the peristome of the shell; generative orifice behind the right eye-peduncle; eye-peduncles long; tentacles stout, very short; no caudal mucus pore or locomotive disk.

Jaw slightly arched, concave edge waved.

Lingual band narrow, central teeth tricuspid, laterals bicuspid, uncini serrated.

Fig. 138. Jaw of *P. muscorum*. (Binney.)

Fig. 139. Dentition of *P. muscorum*. (Binney.)

PUPILLA MUSCORUM (Linæus.)

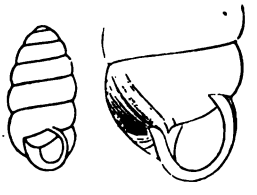


Fig. 140. *P. muscorum*. (Morse.) ×5.

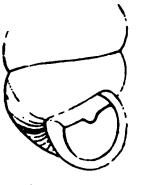


Fig. 141. *Var. unidentata*. (Morse.)

Fig. 142. *Var. bigranata*.

Shell perforate, sub-cylindrical, apex obtuse, dark chestnut color; whorls 6-7, rounded, finely striate; suture deep; aperture nearly circular, small, thickened internally, edentulous; peristome thin, sharp, with a thick, white exterior rib slightly behind it.

Alt. 4, diam. 1½ mm.
Turbo muscorum, Linnæus, Syst. Nat., ed. X., I., 767, (1758).
Pupa ————, W. G. Binney, Man. Am. Land Shells, 78, fig. 40, (1885).
—— ————, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Var. **UNIDENTATA** C. Pfr.

A single denticle on the parietal wall.
Pupa unidentata, C. Pfr., Nat. Deutsch L. & S. Moll. I. pl. III., fig. 19-20, (1821).

Var. **BIGRANATA** Rossmæsler.

Two teeth, one parietal and one basal.
Pupa bigranata, Rossmæsler, Icon. IX., X., 27, fig. 645 (1839).
Easily distinguished from all other Michigan species by its stout, cylindrical form, and strong white rib behind the outer lip. The only localities reported are Grand Rapids and Detroit. The single example from the former locality which I have seen, is the typical edentulous form, but all three forms are represented in the Detroit lot, the unidentate variety, as usual, being the most numerous.

Genus **VERTIGO** Draparnaud.

Fig. 143. Animal of *vertigo*. (Leach.)

Shell deeply rimate, ovate, spire acuminate, apex obtuse, whorls 5-6, convex, the last rounded, aperture semi-oval, with 4 to 7 folds; peristome scarcely expanded, white lipped.

Animal as in *Pupilla*, but lower tentacles wanting.

Jaw more or less arched, ends but little attenuated, blunt; anterior surface with delicate vertical striæ; cutting margin with a more or less developed median projection.

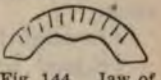


Fig. 144. Jaw of *V. ovata*. (Binney.)

Radula long and narrow; centrals with basal plates higher than wide, sub-rectangular, tricuspid; laterals similar to centrals, but asymmetrical; marginals low, wide, multidentate.

Fig. 145. Dentition of *V. ovata*. (Binney.)

KEY TO SUBGENERA OF *VERTIGO*.

I. Palatal folds simple, no accessory gular fold.....*Vertigo s. s.*
II. A long gular fold deflected at its inner extremity, connected with one of the palatals.....*Vertilla.*

KEY TO SPECIES OF *VERTIGO*.

I. Outer lip flattened, not indented.
a. Aperture regularly rounded below, two columellar teeth, palatal teeth lamellar.....*bollesiana.*
aa. Aperture rounded above, narrower below. One columellar tooth, palatal teeth tubercular.....*tridentata.*

II. Outer lip strongly indented at its upper third.
  a. Shell oval or subcylindrical, last whorl not wider than the penultimate.
    b. Last whorl scarcely higher and narrower than penultimate. Alt. 2.7 mm.....*morsei.*
    bb. Last whorl nearly one-half entire length, wide as penultimate. Alt. 2 mm.....*gouldii.*
    bbb. Penultimate whorl widest, shell very minute. Alt. 4-5 mm. .....*milium.*
  aa. Shell ovate, conic, ventricose, last whorl widest.
    b. Larger, ventricose whorls 5, Alt. 2 mm.....*ovata.*
    bb. Smaller, sub-cylindrical, whorls 4, Alt. 1¾ mm.....*ventricosa.*

Subgenus **VERTILLA** Moquin-Tandon.

Shell minute, last whorl narrowed toward the aperture, which is indented by a deep constriction corresponding to the superior palatal fold, a long gular fold connecting with one of the palatals and abruptly deflected at its inner extremity, columellar lamella long, bulging in the centre and parallel with the columella; inferior palatal smaller than the superior.

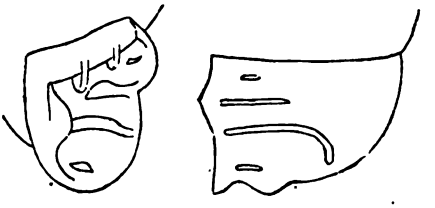


Fig. 146. Arrangement of apertural folds in *Vertilla.* (Sterki.)

VERTIGO MILIUM (Gould).

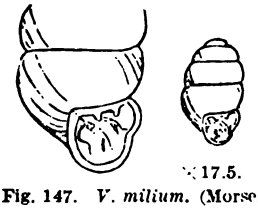


Fig. 147. *V. milium.* (Morse.) ×17.5.

Shell very minute, subcylindrical, diminishing equally to both extremities; dark amber or chestnut color; whorls 5, rounded, very minutely striate; apex obtuse; suture deep, peristome white; aperture within brownish, general shape semi-circular, truncated above by the last whorl, outer lip incurved in the middle, lamellæ 6-8, two parietal, two columellar, two palatal, the superior one large, lamellar, and sharply bent downward at its inner extremity.

Alt. 4-5, diam. 2-5 mm.

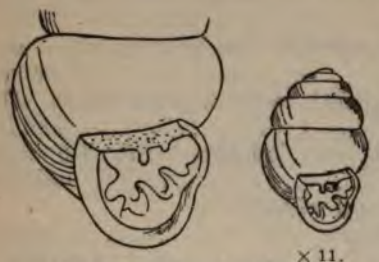
Pupa milium, Gould, Bost. Jour. Nat. Hist. III., 402, pl. III., fig. 23, (1840).
Vertigo ———, W. G. Binney, Man. Am. Land Shells, 332, fig. 361, (1885).
——— ———, Currier, Shell-bearing Moll. Mich., 6, (1865).
——— ———, DeCamp, Shell-bearing Moll. Mich., 7, (1881).
Pupa ———, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Rarely reported, probably on account of its small size. Reported from Newaygo, Kent, Bay, Oakland, Washtenaw and Lenawee counties.

Subgenus **VERTIGO** s. s.

Palatal folds simple; no gular fold.

VERTIGO OVATA Say.



× 11.

Fig. 148. *N. ovata.* (Morse.)

Shell ovate-conic, ventricose, dark amber-colored, smooth, shining; whorls 5, diminishing rapidly to a somewhat acute apex, the last very much inflated, with an indentation toward the aperture; suture deep; peristome thin, somewhat expanded, with a groove behind and thickened within, aperture semi-circular, outer lip strongly incurved in the centre; lamellæ 6-12, 2-3 on the parietal margin, two on the columella, 2-6 on the peristome; umbilicus open.

Alt. 2, diam. 1 mm.

Vertigo ovata, Say, Jour. A. N. S. P., II., 375, (1822).
——— ———, W. G. Binney, Man. Am. Land Shells, 333, fig. 362, (1885).
Pupa ———, Sager, Doc. H. Rep. Mich., 1839, 420, separate 14.
Vertigo ———, Miles, Rep. Geol. Surv. Mich., 236, (1861).
——— ———, DeCamp, Shell-bearing Moll. Mich., 7, (1881).
——— ———, Walker, Rev. Moll. Fauna Mich., 17, (1894).

The most common species of the genus and of general distribution over the entire state. Distinguished from *V. morsei* by its ventricose last whorl and conical spire, and from the other species of the genus by its larger size and usually greater number of apertural lamellæ.

VERTIGO MORSEI Sterki.

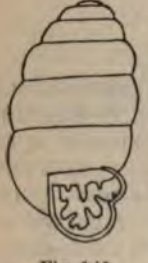


Fig. 149. *V. morsei.* ×13.

Shell cylindrical, turriculate, apex rather acute, imperforate, dark brown, with a few obsolete lines of growth, whorls six, rather slowly and regularly increasing, the last scarcely higher than the penultimate and rather narrow, somewhat sloping toward the base; suture deep; aperture comparatively small, well rounded, thickened within; peristome everted, strongly indented on the outer wall, a moderate crest behind the aperture; a deep and large impression on the body whorl over the palatal folds, and in front of it an impression corresponding with the impression at the auricle; apertural lamellæ typically nine; three on the parietal wall; two on the columella, the columellar strong, with the tip abruptly bent upwards, the subcolumellar horizontal, lamelliform, thin, high and directed obliquely upward; basal small, sometimes double, rarely wanting; palatals high and rather long, curved and directed upward, suprapalatal small, nodule-like.

Alt. 2.7, diam. 1.3; apert. alt. 0.9, lat. 0.8 mm.

Vertigo morsei, Sterki, Naut. VIII., 89, (1894).
——— ———, Walker, Rev. Moll. Fauna Mich., 17, (1894).

The types of this species were discovered by the late Dr. W. H. DeCamp at Dewey's mill near Grand Rapids. Also found in Eaton and Washtenaw counties. It has been found in the post-glacial deposits in Bay and Washtenaw counties.

Easily distinguished from *V. ovata*, which is the only species with which it is likely to be confounded by its greater size, cylindrical shape and peculiar columellar lamella.

VERTIGO VENTRICOSA (Morse).

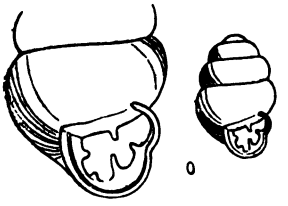


Fig. 150. *V. ventricosa.* (Morse.)

Shell umbilicate, ovate-conic, smooth, polished, whorls 4, convex; suture deeply impressed; aperture semi-circular, thickened within, with 5 teeth, one parietal, two columellar and two palatal; peristome strongly indented.

Alt. 1¼, diam. 1⅛ mm.

Isthmia ventricosa, Morse, Ann. N. Y. Lyc., VIII., 1, fig. 1-3, (1865).
Vertigo ——·——, W. G. Binney, Man. Am. Land Shells, 192, fig. 196, (1885).
——— ———, DeCamp, Shell-bearing Moll. Mich., 7, (1881).
——— ———, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Var. **ELATIOR** Sterki.

Larger and more elevated than the type, ovate to oblong, with rather a pointed apex; a strong callus on the parietal wall, into which the plicæ merge, a strong tooth-like lamella in the base.

Vertigo ventricosa elatior, Sterki, L. & F. W. Moll. New Phila., 5, (1894).
——— ——— ———, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Grand Rapids and Beulah, Benzie county are the only reported localities for the typical form. The variety is more common and has a general range through the lower peninsula.

Smaller, lighter colored and less ventricose than *V. ovata* and more regularly cylindrical, especially the var. *elatior*.

VERTIGO GOULDII (Binney).

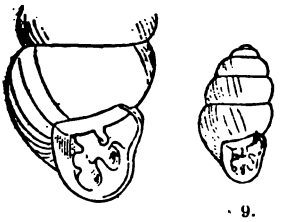


Fig. 151. *V. gouldii.* (Morse.)

Shell perforate, light chestnut, cylindrically ovate, distinctly striate; whorls rather more than four, ventricose, the last occupying nearly one-half of the axis; aperture lateral; palatal wall decidedly flattened or impressed, the impression forming a roundish groove outside and a decidedly projecting angle inside, dividing the peristome into two unequal curves; lamellæ five, one parietal, two columellar and two palatal, white, prominent; peristome thickened, not reflected.

Alt. 2, diam. 1, Alt. aper. ⅔ mm.

Pupa gouldii, Binney, Proc. B. S. N. H., I., 105, (1843).
Vertigo gouldii, W. G. Binney, Man. Am. Land Shells, 190, fig. 191, (1885).
——— *gouldii*, Miles, Rep. Geol. Surv. Mich., 236, (1861).
——— ———, DeCamp, Shell-bearing Moll. Mich., 7, (1881).
——— ———, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Generally distributed over the state, but it is apparently not as common a species as *ovata*, though usually abundant where found. A well marked species, not likely to be confounded with any of the other species found in the state, except, perhaps, *V. ventricosa elatior*, from which it is to be distinguished by its subcylindrical rather than conical shape, striate surface and "position of the tooth-like lamella at the base, somewhat nearer the margin than the end of the columella, the base perceptibly widening at that place."

VERTIGO BOLLESIANA (Morse).

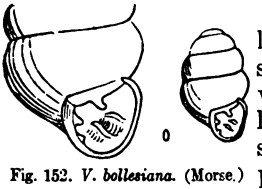


Fig. 152. *V. bollesiana.* (Morse.)

Shell perforate, cylindrical-ovate, delicately striate· light horn-color; apex obtuse; whorls four, subconvex; suture well impressed; aperture sub-orbicular, somewhat flattened on its outer edge but not indented; lamellæ five, one parietal, two columellar and two slightly elevated, lamelliform, within and at the base; peristome subreflected and thickened.

Alt. $1\frac{5}{8}$, diam. $\frac{7}{8}$ mm.

Isthmia bollesiana, Morse, Ann. N. Y. Lyc., VIII., 209, fig. 4-6, (1865).
Vertigo ————, W. G. Binney, Man. Am. Land Shells, 191, fig. 193, (1885).
—— ————, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Rare in Michigan. Petoskey, Charlevoix, Crystal Lake, Benzie county, and Huron mountain, Marquette county, are the only localities reported.

Distinguished by its flattened, not incurved, outer lip, and lamellar teeth on base of aperture.

VERTIGO TRIDENTATA Wolf.

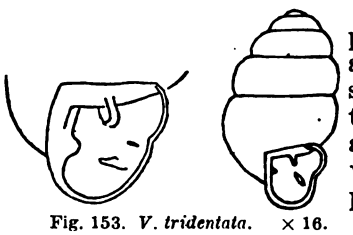


Fig. 153. *V. tridentata.* × 16.

Shell narrowly ovate, amber-colored, highly polished; whorls five, rather convex, smooth, apex obtuse; suture impressed; aperture very slightly thickened within, apertural lamellæ typically three, one parietal, one columellar and one palatal, forming a regular triangle, a very minute upper palatal is occasionally present.

Alt. 1.66, diam. 1.1 mm.

Vertigo tridentata, Wolf, Am. Jour. Con., V., 198, pl. XVII., fig. 1, (1870).
—— ————, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Apparently rare, but probably overlooked on account of its size. Ann Arbor and Grand Rapids are the only localities thus far reported. A well marked species characterized by its regularly ovate outline, few and small apertural lamellæ and very slight internal thickening of the outer lip. The figure of the aperture is copied from that of Sterki.

Family **COCHLICOPIDÆ.**

Shell oblong, cylindric-oblong or narrowly tapering, smooth and glossy, with imperforate axis; aperture ovate or acuminate, the columella notched below or continuous with the basal lip. Foot without pedal grooves. Kidney with direct ureter, of the Basommatophorus type. Genitalia with a long appendix on the penis.

Jaw vertically striate, thin, arcuate.

Radula with central tooth small, tricuspid; central cusp long and narrow; side cusps of subequal length; laterals bicuspid; marginal teeth low, wide, multidentate.

Genus **COCHLICOPA** (Fer.) Risso.

Shell ovate-oblong, imperforate, smooth, pellucid, glistening, dark horn-colored; whorls rather convex; aperture less than half the shell's length,

Fig. 154. Animal of *C. lubrica.* (Binney.)

ovate; columella more or less truncated; peristome blunt, its margins joined by a callus.

Animal heliciform, obtuse before, pointed behind; mantle subcentral, thin, simple, protected by a shell; anal and respiratory orifices on the right of the mantle under the peristome of the shell; generative orifice behind the right eye-peduncle; no locomotive disk; no caudal mucus pore.

Fig. 155. Jaw of *C. lubrica.* (Binney)

Jaw low, slightly arcuate, wide, with but little attenuated, blunt ends; cutting edge with a slightly produced, wide, median projection; anterior surface without ribs, but with fine vertical striæ. There is a strong muscular attachment on its upper margin.

Lingual membrane; centrals with basal plates small and narrow, expanding at lower angles, tricuspid; laterals subrectangular, bicuspid, asymmetrical; marginals low, wide and multidentate.

Fig. 156. Dentition of *C. lubrica.* (Binney.)

COCHLICOPA LUBRICA (Muller).

Fig. 157. *C. lubrica.* ×3¾ (Binney.)

Shell imperforate, oblong-oval; smoky horn-color, smooth, and shining; whorls 5-6; somewhat rounded, the last two-fifths of entire length, rounded at base; apex obtuse; suture somewhat impressed; aperture oval, longitudinal, peristome simple, thickened, often slightly rufus; columella obtusely truncated at base.

Alt. 6, diam. 2½ mm.

Helix lubrica, Muller, Verm. Hist., I., 104, (1774).
Ferussacia subcylindrica, W. G. Binney, Man. Am. Land Shells, 194, fig. 202, (1885).
Achatina lubrica, Miles, Rep. Geol. Surv. Mich., 236, (1861).
Zua subcylindrace, Currier, Shell-bearing Moll. Mich., 6, (1865).
—— *subcylindracea,* DeCamp, Shell-bearing Moll. Mich., 7, (1881).
Ferussacia subcylindrica, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Var. MORSEANA Doherty.

Longer and more slender than the typical form.

Alt. 7, diam. 2 mm.

Cionella morseana, Doherty, Jour. of Con., I., 342, pl. IV., fig. 2, (1878).

The typical form is generally distributed all over the state. The variety has thus far been detected only in Ontonagon county.

Family VALLONIIDÆ.

Jaw arcuate, lower margin with or without a median projection; lingual membrane similar to that of the *Pupillidæ,* central tooth narrower than the

laterals, tricuspid, laterals quadrate, marginal teeth wide and low, multicuspid.

Shell minute, heliciform, depressed, umbilicated, aperture subcircular or short oval, peristome elevated or straight, with or without a whitish lip; no apertural lamellæ or folds.

Genus **VALLONIA** Risso.

Shell minute, openly and widely umbilicate, depressed; the spire low-convex, consisting of 3-4½ whorls; color light and uniform; surface smooth or ribbed; periphery rounded; last whorl usually descending in front. Aperture oblique, circular or short oval; peristome continuous or nearly so, expanded or reflexed, often thickened within. Foot small, short with no pedal grooves; edges of sole somewhat crenulated; sole undivided; eye-peduncles cylindrical, not enlarged distally; tentacles short; labial lobes well developed.

Fig. 128. Jaw of *V. pulchella*. (Sterki.)

Genitalia having the penis short with terminal retractor; epiphallus short bearing a flagellum. Dart sack present, containing a straight, bladeless dart. No mucus glands. Duct of spermatheca long, branchless.

Jaw arcuate with a slight medina projection or none, sculptured with numerous (18 to 25) crowded, low riblets denticulating the margins.

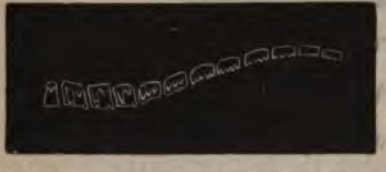


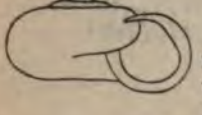
Fig. 159. Dentition of *Vallonia*. (Binney.)

Radula having twenty-three to thirty-three teeth in a transverse row, median teeth decidedly narrower than laterals, tricuspid, the mesocone not half as long as the basal plate, side cusps smaller. Laterals with large square basal plates, the mesocone extending to its edge, ectocone small; marginal teeth wide and low, multicuspid.

KEY TO THE SPECIES OF *VALLONIA*.

I. Surface smooth or very finely striate.
  a. Umbilicus regularly rounded..... *pulchella*.
  aa. Umbilicus elongate..... *excentrica*.
II. Surface with distinct, membranous ribs..... *costata*.

VALLONIA PULCHELLA (Muller).



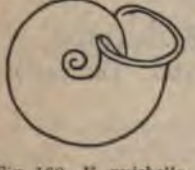


Fig. 160. *V. pulchella*. (Sterki.) × 10.

Shell moderately umbilicated, the umbilicus regularly rounded; slightly convex above; straw-colored or whitish, transparent, with fine and dense striæ; whorls 3½-4, the last comparatively large, well rounded, little expanded toward the aperture; suture moderately deep; aperture nearly circular; peristome abruptly everted, with a strong white lip, thinner at either end.

Alt. 1.2, greater diam. 2.4, lesser 2 mm.

Helix pulchella, Muller, Verm. Hist., II., 30, (1774).
Vallonia ———, W. G. Binney, Man. Am. Land Shells, 77, fig. 39, (1885).
Helix ———, Miles, Rep. Geol. Surv. Mich., 236, (1861).
Vallonia minuta, Currier, Shell-bearing Moll. Mich., 5, (1868).
——— ———, DeCamp, Shell-bearing Moll. Mich., 6, (1881).
——— *pulchella*, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Common and of general distribution in the lower peninsula. Not yet reported from the upper peninsula, except on Isle Royale.

The *Vallonia* are easily distinguished from the other genera represented in our fauna by their small size and strongly reflected white lip. The regular rounded umbilicus and scarcely expanded body-whorl are very characteristic of this species, and when typical, it can easily be separated from *V. excentrica*, but occasional examples are often difficult to determine.

VALLONIA EXCENTRICA Sterki.

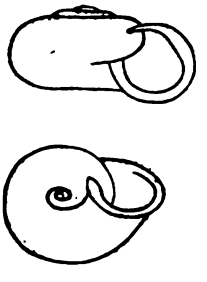


Fig. 161. *V. excentrica.* (Sterki.) ×10.

Shell moderately umbilicated, the umbilicus elongate; slightly convex above, pale horn colored; transparent or slightly opaque, smooth or very finely and irregularly striate, whorls 3-3½; the last comparatively large, well rounded, expanding toward the aperture; suture moderately deep; aperture nearly circular, subangular at the base, the umbilical margin somewhat protracted; peristome everted only in the inferior part, with a strong white lip, shining through the shell.

Alt. 1.1, greater diam. 2.3, lesser 1.8 mm.

Vallonia excentrica, Sterki, Man. Con., VIII., p. 249, pl. 32, fig. 6-9, (1893).
——— ———, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Apparently of general distribution in the southern part of the lower peninsula. Not yet reported north of Newaygo county. Typically easily distinguished by the peculiar shape of the umbilicus and the expanded form of the last whorl toward the aperture.

VALLONIA COSTATA (Muller).

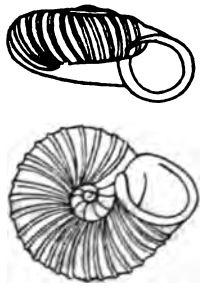


Fig. 162. *V. costata.* (Sterki.) ×10.

Shell moderately umbilicated, depressed, convex above, or nearly flat; grayish to light or reddish horn-colored; with rather regularly set, membranous ribs and finer striæ between them; whorls 3½, at the circumference somewhat angular, with a deep suture; the last whorl expanding to the aperture, sharply and moderately descending in front; aperture almost circular, a little flattened above, peristome strongly and abruptly everted with a strong white lip.

Alt. 1.1, greater diam. 2.5, lesser 2.1 mm.

Helix costata, Muller, Verm. Hist., II., 31, (1774).
Vallonia ———, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Rare in Michigan. Owosso, Shiawassee county, Isle Royale and Monroe are the only recorded localities.

Suborder BASOMMATOPHORA.

Superfamily GEHYDROPHILA.

Tentacles contractile, subcylindrical. Eyes sessile at the inner sides of the bases. Operculum wanting. Genital orifices separated but on the same side. Tegument rugose as in the *Stylommatophora*.

Family AURICULIDÆ.

Shell spiral, covered with a heavy epidermis; aperture elongate or oval, with strong folds on the columella; outer lip often dentate. Internal septa usually absorbed.

Head ending in a snout; mouth with a heavy lunate jaw, and with two dilated buccal lobes, united above, separated below; tentacles cylindrical, contractile; eyes sessile at the under sides of the bases. Mantle closed, with a thickened margin; foot long, posteriorly blunt; respiratory orifice posterior on the right side, excretory orifice near it. Sexes united, orifices of generative organs distant, on the right side.

Genus CARYCHIUM Muller.

Shell pupæform, very thin, transparent, with but few whorls; aperture sub-oval, with one dentiform columellar fold, sometimes obsolete; parietal wall with one or two teeth; peristome expanded; extremities united by a parietal callus, the right hand one with one internal tooth.

Fig. 163. Animal of *C. exiguum*. (Binney.)

Tentacles relatively large, cylindrical, obtuse, eyes situated below and behind the tentacles near their base; foot thick, obtuse behind, not transversely divided beneath.

Fig. 164. Jaw of *Carychium*. (Moquin-Tandon.)

Jaw slightly arched, without ribs or marginal denticulations, broadly striated towards the margin.

Teeth in slightly bent cross series; centrals equilateral, narrow; laterals broad, short, denticulated.

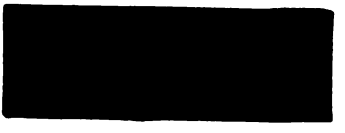


Fig. 165. Dentition of C. *exiguum*. (Binney.)

CARYCHIUM EXIGUUM (Say).

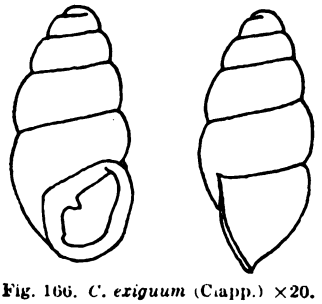


Fig. 166. *C. exiguum* (Clapp.) ×20.

Shell minute, perforate, cylindrical, apex obtuse, white, translucent, shining; whorls 4½, regularly convex, nearly smooth, the last two of about equal diameter; suture impressed; aperture obliquely oval, decidedly more than one-third the total altitude; outer lip reflected, sinuous, moderately thickened, very strongly arcuate at the upper outer portion; columellar margin having an obtuse fold below and a prominent entering fold above.

Alt. 1.75-2.15, diam. .75-.85 mm.

Pupa exigua, Say, Jour. A. N. S. P., II., 375,(1822).
Carychium exiguum, W. G. Binney, L. & F. W. Shells, II., 6, fig. 8, (1865).
———— ————, Miles, Rep. Geol. Surv. Mich., 236, (1861).
———— ————, Currier, Shell-bearing Moll. Mich. p. 6, (1868).
———— ————, DeCamp, Shell-bearing Moll. Mich., 7, (1881).
———— ————, Walker, Rev. Moll. Fauna Mich., 17, (1894).

This minute, slender, white species is semi-amphibious in its habits, and has a general distribution over the entire state. Distinguished from *C. exile*, by its shorter, more inflated shape and nearly smooth surface. The larger examples noted above are analogous to the var. *canadense* of *C. exile*, but they are more discontinuous in their range and seem rather to be the effect of specially favorable conditions of environment rather than a true race.

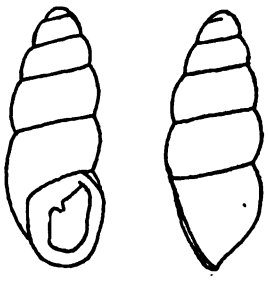


Fig. 167. *C. exile.* (Clapp.) ×20.

CARYCHIUM EXILE H. C. Lea.

Shell minute, elongated, cylindrical, apex obtuse, white, transparent, shining; whorls 5-5½, somewhat shouldered, closely, regularly and distinctly striate; suture deeply impressed; aperture small; very oblique, about one-third the length of the shells; outer lip reflected, more or less thickened; columellar having an obtuse fold below and a prominent entering fold above.

Alt. 1.75, diam. .6 mm.

Carychium exile, H. C. Lea, Am. J. Sc. (1), XLII., 109, pl. I., fig. 5, (1841).
———— ————, Walker, Rev. Moll. Fauna Mich., 17, (1894).

Var. **CANADENSE** Clapp.

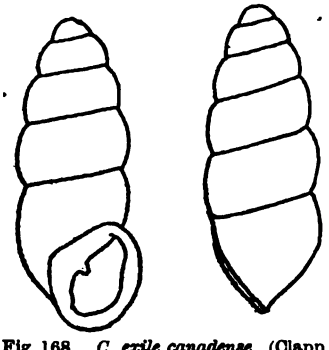


Fig. 168. *C. exile canadense.* (Clapp.) ×20.

Uniformly larger.

Alt. 2.1, diam. .75 mm.

Carychium exile canadense, Clapp, Naut. XIX., 138, pl. VIII., figs. 1, 2, 6 and 7, (1906).

This species is easily separated from *C. exiguum* by its more slender, elongated shell, which is distinctly striate. The typical form is apparently rarely found in the southern part of the state, having been recognized only from Saginaw and Shelby, Macomb county. The variety is characteristic of northern part of the state where it ranges from Roscommon county northerly through the entire upper peninsula.

UNAUTHENTICATED AND DOUBTFUL SPECIES.

POLYGYRA PALLIATA ALBA (Currier).

Listed, but without description, by Currier in his catalogue of 1868, where it is stated that it is in "my cabinet." I have been entirely unsuccessful in locating this form. It is not now in the Currier collection, which is in the possession of the Kent Scientific Museum of Grand Rapids. Nor has it been found by any of the other collectors of the state.

POLYGYRA THYROIDES BUCCULENTA (Gld.)

Cited by DeCamp. The citation from my own collection in my catalogue of 1894 was based on specimens received from DeCamp so labeled and accepted without due care. All of DeCamp's specimens are now in my possession and prove to be *Polygyra albolabris maritima*. The form must therefore be dropped as a member of our fauna.

SUCCINEA HIGGINSI Bld.

Judging from the original figure and description, it seems questionable whether this is more than a dentate variety of *S. retusa* Lea. A similar form of the European *S. putris* L. has been noticed by Baudon. No dentate specimens of *Succinea* from Michigan have been seen and the edentulous form doubtfully referred in prior lists to this species should be placed elsewhere. It follows that the species should be dropped from the Michigan list.

SUCCINEA CAMPESTRIS Say.

The obviously erroneous citation of this species by Sager and Miles was caused, so Dr. Miles states in his report to the Census, by following Gould's error, in the first edition of the Invertebrata of Massachusetts, of referring *S. obliqua* to *campestris*.

SUCCINEA AUREA Lea.

Cited by DeCamp, whose specimens, now in my possession, are young *retusa*.

PUPA DECORA Gld.

Cited by DeCamp from Kent county, but his specimens proved to be the types of a new species, *Vertigo morsei* Sterki.

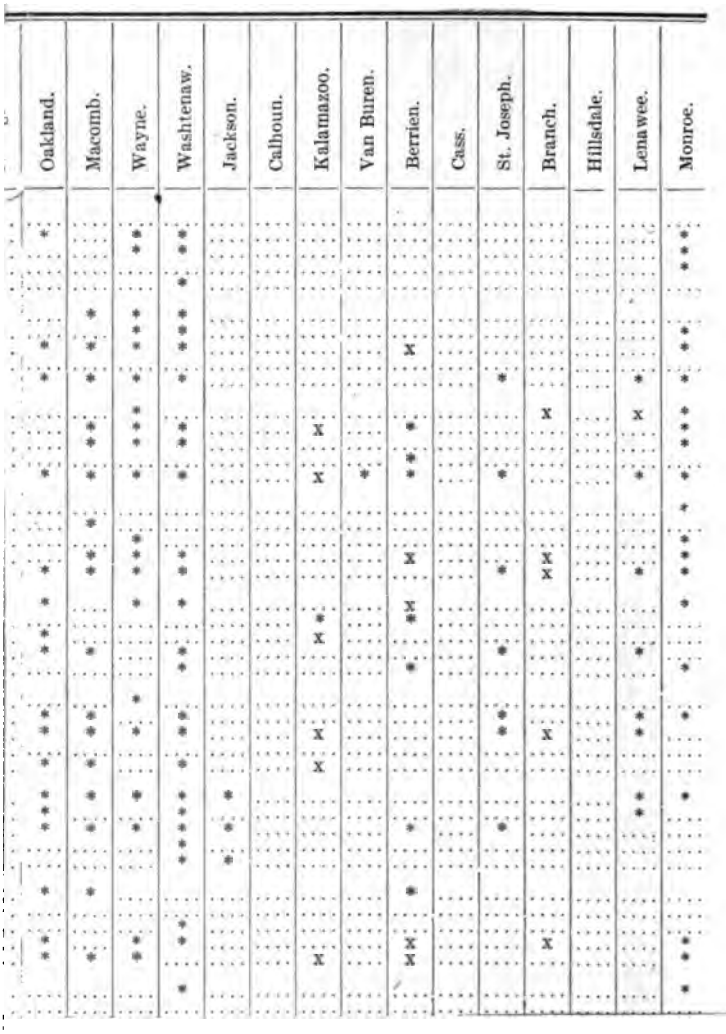
HELICELLA VIRGATA (DaCosta).

A single dead specimen of this species said to have been collected at Flint was in the Lathrop collection (See Naut. VI, p. 125).

VERTIGO PUSILLA Muller.

Fig. 169. *V. pusilla.* (Vanatta.) ×22.

A specimen of this European species was recently discovered in a vial of *Cochlicopa lubrica* from Lansing, sent by Dr. Manly Miles to the Philadelphia Academy of Natural Science more than thirty years ago. The vial had not been opened during that time. As this species has never been recorded from this country, it is in all probability a stray specimen that was inadvertently mixed with the Michigan shells. It is characterized by its sinistral shell and peculiar arrangement of the apertural folds. The accompanying figure of the specimen in question made by Mr. Vanatta will enable it to be identified should it ever occur again.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SEVENTH ANNUAL REPORT

OF THE

STATE GEOLOGIST,

ALFRED C. LANE

TO THE

BOARD OF GEOLOGICAL SURVEY

FOR THE YEAR 1905.

ACCOMPANYING THE PRECEDING PAPERS.

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Paint	566
Iron Ore	567
Coal	568

ILLUSTRATION.

Fig. 169, Illustrating the occurrence of iron ore on the Gogebic range 568

ANNUAL REPORT FOR 1905.

OFFICE OF THE STATE GEOLOGIST,
LANSING, MICHIGAN, Dec. 14, 1905.

To the Honorable the Board of Geological Survey of the State of Michigan:

HON. F. M. WARNER, *President.*
HON. W. J. MCKONE.
HON. P. H. KELLEY, *Secretary.*

Gentlemen—I beg to submit my report[1] for the fiscal year July 1, 1904, to June 30, 1905, in continuation of previous reports, and for the calendar year for 1905. This disparity of dates is in order to give time to make up the figures and at the same time give prompt account of the last field season.

The following is the usual tabular statement of expenses from the annual appropriation (Act No. 133, Session of 1895):

FINANCES.

	Salary.	Field.	Office.	Total.
July	$835 16	$266 64	$63 42	$1,165 22
August	1,031 16	267 66	24 33	1,323 15
September	886 59	368 65	44 90	1,300 14
October	581 77	105 33	26 33	713 43
November	423 00	23 46	27 63	474 09
December	378 50	36 50	19 23	434 23
January	375 42	34 06	32 91	442 39
February	365 60	.....	37 20	402 80
March	488 79	.....	40 41	529 20
April	354 80	.....	20 50	375 30
May	328 79	.....	5 55	334 34
June	424 80	61 79	19 12	505 71
Supplementary	.....	.....	.....	.....
Total	$6,474 38	$1,164 09	$361 53	$8,000 00

Our expenses to December 14, 1905, are $3,488.80. Beside this we have expended; from the appropriation for the joint topographic survey with the U. S. Geological Survey (which has been expended in mapping areas—Marquette and Detroit), Act 251, 1905, $1,996.58, and from Act 178, Session 1903, $499.65.

[1] A full abstract of this report was published in the "Michigan Miner" for March, 1906.

The last legislature in authorizing your Board to conduct a biological survey (a study of peat producing plants), in amending the act in the very last days of the session, made the appropriation therefor $1,000 for the year 1905, and $1,000 for the year 1906. Although the obvious intention of the legislature was to provide for the field season of 1905 and of 1906 respectively, the ruling of the Auditor General's department is that it legally applied to the year ending June 30, 1905, and must be spent *or contracted for* by that time. Under the circumstances the wisest expenditure seemed as follows: Prof. C. A. Davis of Ann Arbor had been for some time studying the plants of the peat bogs, especially in the Lower Peninsula, and had prepared an elaborate thesis thereon. This we agreed to purchase on condition that he would complete the same by spending his whole summer in travel and further investigation of the plants and peat bogs of the Upper Peninsula, without further expense to us, and hand in then a complete report on the distribution of the peat producing flora of the State. This he has done and I recommend it to you for publication as part of the report for 1905.

The expenses for printing are as follows:[1]

Appropriation Section 1, Act 271, Session 1901			$2,800 00
Expended (p. 118 annual for 1904 and p. 307, annual 1903) previously		$1,949 17	
Finishing up report for 1903		126 20	
Expended up to July 1, 1905		$2,073 41	
Appropriation Section 1, Act 178, Session 1903:			
First half—			
Expended up to Oct. 27, 1904		$655 90	
For annual for 1903	$93 30		
For miscellaneous	35		
For Volume IX	552 25		
Expended to July 1, 1905:			
For Volume IX	51 99		
For annual for 1903	531 06		
Total	$583 05		
Total		$1,238 95	
Second half—			
Binding of Volume IX	$487 50		
Incidental	105 00		
Annual for 1903 and 1904			
Total		$1,238 41	

[1] Owing to the allotment for the annuals for 1903 and 1904 being insufficient, I had to cancel the printing done on the Douglass Houghton report, paying for the little that had been done (fortunately the printer had been very slow) out of my own pocket, and use the balance of the appropriation, Section 1, Act 231, Session 1901, to finish Volume IX and the two annuals, which included a number of expensive maps.

PUBLICATIONS.

This year shows a better record than last as to publications. The annual report for 1903, containing contour maps of Bay and Tuscola counties, and of Ann Arbor showing also the wooded areas, with a report on the Soil and Forest types of the Michigan Forestry Reserve, by B. E. Livingston, a discussion of the water resources of the lower tier of counties by W. F. Cooper, and of the Upper Peninsula, and of the propagation of heat into the ground, which affects mine and well temperatures, etc., papers on the copper bearing formations, etc., was finally finished by the Robert Smith Printing Co.

The new state printers, the Wynkoop, Hallenbeck, Crawford Co., also pushed through the annual for 1904, which contains a paper on the failure of the wells along the Lower Huron river by M. L. Fuller, an account of the geology of the north shores of Lakes Huron and Michigan by I. C. Russell, and my personal report, which contains besides notes on current accumulation of facts regarding wood substitutes, coal, gold mining, wells and borings, an account of the recent committee on the iron bearing rocks.

Volume IX of our reports consisting mainly of Grimsley's monograph on the gypsum has also been published although it was nearly ready a year ago.

Of the joint topographic survey sheets has been issued that of Grosse Point, covering the Detroit Water Works and Belle Isle Park—Lon. 82° 45′-83°, Lat. 42° 15′-30′ N. Eight other sheets may be expected soon.[1]

I have carefully studied not to make our publications unduly expensive and think I have succeeded fairly well. It must of course be remembered that our small editions make the cost per copy high. Yet there is no use in running off large editions, increasing the total cost, simply to reduce the cost per page or volume. If the object were to advertise the resources of the State to a large class, like that of prospective emigrants, it would be different. We do have quite a large call for the small map which we use also as a letter back.

But as I understand the situation, the better plan is to put on record and in the libraries where they could be consulted by all, and in the hands of those teachers who have interest enough to ask for and use them, important facts that may be discovered regarding the resources and geology of the State, and depend upon the journalist and magazine to spread abroad those matters which are of interest to a wider circle.

I am consulted (gratis) very frequently in my office regarding boring and raw material of various kinds. With the facts in our reports readily at hand I can often give information worth perhaps a good deal of money to the inquirer, and ultimately lead to an increase in the taxable property of the State. Yet the information in question would be of similar value to comparatively few.

The main object should be to get the facts into the hands of those who can appreciate them, and I believe that can be done by making the subject and author of each paper conspicuous and the Board acting as publisher and using the ordinary channels of the book trade. The work on gypsum by G. P. Grimsley for instance will find its way into the hands of those interested much quicker when thus entitled than as Part 2, of Volume IX of the report of the Geological Survey of Michigan.

I believe it might also be well to place the publications of the Board on sale at a commission with booksellers in central towns and towns imme-

[1] Now out, Nov., 1906, apply to Director U. S. Geol. Survey, Washington, D. C.

diately interested. I have no doubt many dwellers on the St. Clair Flats would be glad to buy Mr. Cole's report did they but know of it.

I may also mention (see note on co-operation below) the fact that soil maps have been issued by the U. S. Department of Agriculture, in addition to those of Allegan county and Pontiac, around Alma, Saginaw and Bay City, Owosso and Munising.

The College of Mines at Houghton has also issued a pamphlet on Michigan minerals and rocks to accompany their loan collections which should be invaluable to teachers.

LEGISLATION.

The last legislature passed an act extending the work of the Board to cover a biological survey, that is a study of the distribution not merely of the rocks but of the plants and animals, its relation to their environment and the welfare of man. In consequence it became difficult for me to estimate what amount of money might be needed for expenses. I had therefore to ask the legislature to let the report come out of the general funds under the same law that covers those of numerous other boards. This is Act 44 of the Public Acts of 1899, and was amended by Act 297 of the Session of 1905 in section 14 by adding "State Board of Geological Survey" "not to exceed 1200" at the end. These 1200 copies are to be distributed "by the head of the department," about 125 copies are issued for the State Library and about 200 for the Secretary of State in addition. Thus volumes uniform with those bound in green are suspended until further action, and reports will be of the same general style as those annual reports issued at intervals since 1892.

But there is no curtailment in the size of the printed page, merely in the margin, and somewhat in the quality of the ordinary paper. But I hope that there will be no deterioration so far as the illustrations are concerned.

The Board of Auditors I think intelligently appreciate that the quality of the illustrations is essential in a report of this kind.

A further sum was granted to continue the joint topographic survey of the State.

Below will be found copies of the acts providing for the biological survey (No. 250) and the joint topographic survey (No. 251). It hardly seems worth while to reprint the act regarding printing for a single line amendment.

Another act which may mean work for the geologist in future is one regulating the use of flowing wells. (Act No. 107.) This is the third act respecting such matter that has been passed by the legislature, the others being one regulating abandoned salt wells, and another regarding artesian wells, which seem intended to cover the same ground as the more recent bill. Water is one of the essentials of life and unquestionably in the future the State will have to step in more and more to regulate problems involving conflicting claims on the use of water, for the greatest good of the greater number. A stream may be used for drinking and for sewage disposition. It is not healthy to use it for both! Wells are commonly used as sources of water supply, but in many cases they may be efficiently used as drains. Many a little pocket marsh can be effectively drained in that way. But the two uses may clash.

A free use of water as a motor for a hydraulic ram may appreciably lower the head elsewhere. Now while the respective rights to surface water are

pretty well settled little has been determined regarding rights to underground water, an animal "*feræ naturæ*," perhaps according to the common laws, the ways of which it used to be thought one could find out. Much has been done, however, in this connection of late years, especially by the U. S. Geological Survey, in gathering the facts which are the prerequisite to intelligent legislation. This applies as well to the streams of the State. The people should soon decide whether they prefer to use them as sources of water or sewers. That they should continue long to be used for both will become with our increasing population and intelligence incredible, unless both products are systematically filtered.

ACT NO. 250.

AN ACT to provide for a biological survey of the State, making appropriations therefor, and to provide a tax to meet the same.

The People of the State of Michigan enact:

SECTION 1. That the Board of Geological Survey as constituted by act number sixty-five of the laws of eighteen hundred sixty-nine, as amended, is hereby authorized and required to make under the general direction of the State Geologist, appointed by them, a thorough biological survey of the State, embracing a determination of the range and distribution of the various plants and animals inhabiting the State and the relation to their environment and the welfare of man.

SEC. 2. The powers and duties of said board relative to the expenses incident to such biological surveys, and the publication thereof shall be the same as they now are relative to the geological and mineralogical survey of the State.

SEC. 3. The annual report of progress now required of the Board of Geological Survey shall include an account of the progress of said biological survey and there shall be printed of the same, the same number as, and under the same conditions as, the report of the Board of Fish Commissioners as provided in act number two hundred twenty-five of the Public Acts of nineteen hundred three.

SEC. 4. To carry into effect the conditions of this act, the sum of one thousand dollars for the year nineteen hundred five, and one thousand dollars for the year nineteen hundred six, is hereby appropriated to be drawn from the treasury as needed. The accounts of the members of the board for official services and all other expenses authorized by law shall first be certified to be correct by said board, and shall be paid out of the State treasury upon the warrant of the Auditor General from the fund appropriated for that purpose: Provided, No part of said appropriation shall be used for printing reports.

SEC. 5. The Auditor General shall add to and incorporate in the State tax for the fiscal year ending June thirty, nineteen hundred five, the sum of one thousand dollars, and for the fiscal year ending June thirty, nineteen hundred six, the sum of one thousand dollars which, when collected, shall be credited to the general fund to reimburse the same for the money hereby appropriated.

This act is ordered to take immediate effect.

ACT NO. 251.

AN ACT providing for the extension of the work of the State Board of Geological Survey and making an appropriation to meet the expense thereof, and providing a tax to meet the same.

The People of the State of Michigan enact:

SECTION 1. That the Board of Geological Survey, as constituted by act number sixty-five of the laws of eighteen hundred sixty-nine and acts amendatory thereof, is hereby authorized to confer with the director or representative of the United States Geological Survey and to accept its co-operation which this State in the preparation and completion of a contour topographical survey map of this State, which is hereby authorized to be made. Said board shall have power to arrange with the director or representative of the United States Geological Survey concerning this survey and map, its scale, method of execution, form and all details of the work, in behalf of this State, and accept or reject the work executed by the United States Geological Survey. And it is hereby provided that said map shall accurately show the outline of all townships, counties, and extensive wooded areas, in this State as existing on the grounds at the time of the execution of

these surveys; the location of all roads, railroads, streams, canals, lakes, and rivers; and shall show by contour lines the elevation and depression of the surface of the country. For the purpose of making the surveys hereinbefore provided for, it shall be lawful for the persons employed in making the same to enter upon all lands within the boundaries of this State, but this act shall not be construed as authorizing any unnecessary interference with private rights.

SEC. 2. That there be and is hereby appropriated for the purpose described in the preceding section of this act, and for the work of the board, as heretofore authorized, the sum of two thousand dollars for the year ending June thirty, nineteen hundred six, and the sum of three thousand dollars for the year ending June thirty, nineteen hundred seven.

SEC. 3. The several sums appropriated by the provisions of this act shall first be certified to be correct by said board, and shall be paid out of the State treasury upon the warrant of the Auditor General from the fund appropriated for the purpose: Provided, That bills for expenses for printing and publication shall, after approval by the board, be presented to the Board of State Auditors, and after allowance by them audited by the Auditor General: And provided further, That the expenditures for the topographical survey shall not be in excess of that expended by the United States Geological Survey from the United States treasury.

SEC. 4. The Auditor General shall add to and incorporate in the State tax for the fiscal year ending June thirty, nineteen hundred five, the sum of two thousand dollars, and for the fiscal year ending June thirty, nineteen hundred six, the sum of three thousand dollars, which, when collected, shall be credited to the general fund to reimburse the same for the money hereby appropriated.

This act is ordered to take immediate effect.

ACT NO. 107.

AN ACT to regulate the use of artesian and other wells; to prevent the waste of waters therefrom, and provide a remedy therefor.

The People of the State of Michigan enact:

SECTION 1. Any artesian or flowing well, the water of which is unnecessarily allowed to run to waste in an unreasonable manner to the depletion or lowering of the head or reservoir thereof to the detriment or damage of other wells supplied from the same head or reservoir, shall be deemed a nuisance, and its owner and the owner of the land on which it is situated shall be subject to all the actions for abatement and damages in favor of the person or persons injured that are or may be provided by the law for other nuisances or tortious acts.

SEC. 2. Where any well is supplied by a head, reservoir, stratum, or vein or by percolating waters common to other springs or wells, and the owner thereof or his lessee or licensee puts its waters to a use unreasonable or unnecessary, in view of the condition and situation of the land on which it is situated, and through such unreasonable or unnecessary use, lowers or depletes the head, pressure, or supply of water of any spring or well dependent on the same head, vein or stratum, to the detriment or injury of the owner or any person entitled to the use thereof, the well so unreasonably and unnecessarily used, shall be deemed to be a nuisance, and its owner and the owner of the land on which it is situated shall be subject to all the actions for abatement and damages in favor of the person or persons injured, that are or may be provided by law for other nuisances or tortious acts.

SEC. 3. Where any decree is rendered under this act declaring any well a nuisance because of the waste or unreasonable use of its waters and directing the abatement thereof, such decree shall specify in some practicable manner the daily amount or volume of water that may be used or allowed to flow therefrom without violating such decree, and specify such reasonable time as to the court shall seem just within which the provisions thereof shall be carried into effect: Provided, That any such decree may be reopened at any time after entry on the question of reasonable use on a proper showing of change of circumstances or other equitable reason therefor.

This act is ordered to take immediate effect.

BIOLOGICAL SURVEY.

Upon the passage of the biological survey act I invited leading and easily accessible biologists, who had been active in behalf of the bill, to consult

with me as to what should be done. There were present Mr. G. M. Bradford of Bay City, Prof. J. B. Dandene, W. B. Barrows, and J. W. Beal of the M. A. C., C. C. Adams and C. A. Davis of the University, Bryant Walker of Detroit, and A. C. Lane.

Dr. H. L. Clark of Olivet, E. N. Transeau of Alma, and Drs. Reighard and Newcombe of the University were represented by letter.

The general opinion was that it would be wise to have an advisory committee, regarding the Biological Survey especially, to consist of one member from outside the State institutions to be nominated by the council of the Academy of Sciences, and one each from the Botanical and Zoological Departments of the Agricultural College and University. If it were deemed wise to have this advisory committee include the whole scope of the survey a geologist from the University and College of Mines might be added. It was deemed proper that hereafter in running heads and citations the term "Michigan Survey" be used, and the proposition of the State Geologist that all the papers should be published in one volume per year, each paper to be issued as ready with a separate date of issue, but to be paged continuously for a single year seemed generally satisfactory.

Among the propositions for work were the following: (1) A study of the distribution and present abundance of venomous snakes in Michigan. (2) A study of the plants most concerned in the production of peat. (3) A biological survey of some small area of which we already have a soil map of the department of agriculture. (4) A botanical study of Bay county. (5) A study of the trees and shrubs of the State, probably in co-operation with the forest reserve. (6) A study of the edible fishes in connection with the study of certain select and typical lakes. (7) The State Geologist also suggested that in connection with any or all of this work biologists might be attached to geological parties working in the Upper Peninsula. (8) It was suggested that Mr. Bryant Walker give a report on the Molluscs of the State. To this Mr. Walker said that he could in a short time prepare an account of the land snails of the State, but that it would take considerable more time to cover all the fresh water fauna; that he had already acquired cuts, however, of a very large number of species.

There seemed to be a very general consent that *one* of the pieces of work undertaken should concern the fish resources of the smaller lakes, but some difficulty in deciding just how this would be at present undertaken.

The State Geologist will thankfully appreciate suggestions.

CONSTITUTION OF THE BOARD OF GEOLOGICAL SURVEY.

There has also been some talk to me, in connection with this enlargement of the scope of the work of the Board, of lengthening the title so as to include Natural History and changing my own title also to that of Director, enlarging the membership of the Board by appointees from the scientific departments of the State institutions. While I recognize that would tend to keep a closer check on my scientific work and be a stimulus to me, and while I feel and appreciate the help that such members would be to me in the broader field now before us, which the attainments of no *one* man may span, yet there are certain practical difficulties which ought not to be forgotten. The present Board are ex officio and the expenses of the same are a minimum—only about $100.00 a year. Many members have not drawn a cent from the State Treasurer for their work on the Board. At a time when accusa-

tions of graft, often well founded, spread like wild fire even where ill founded, it is worth noting that not one of the Governors with whom I have been associated has used his position on the Board for personal profit or to pay political debts.

One reason then that might be urged for such an enlargement of the Board, to "take it out of politics," can therefore only be brought forward as a guard against future rather than a remedy for present or past evils.

Human nature I have found much the same whether occupying professional chairs or political posts. Some men are selfish, some unselfish. Some work for themselves, others work for the cause.

It would be difficult to enlarge the Board and give all interests due representation without making it unwieldy, hard to obtain a quorum, and expensive to have meetings.

Lengthening my title or that of the Board would mean a slight addition to the expense, and I find upon examination that there is plenty of precedent for biological work in connection with a geological survey and nominally supervised by the "State Geologist." Possibly good results could be obtained by selection of official advisers or consulting scientists, somewhat as is the system in Wisconsin, and I would recommend that this Board adopt such a plan tentatively on its own initiative, and then later if it works satisfactorily it might be incorporated as a part of the law. I submit to the careful consideration of the Board the following series of resolutions by which such a plan might be inaugurated.

Resolved, That this Board select six official scientific advisers, two geologists, one at least of whom shall be a resident of the Upper Peninsula, two botanists (not connected with the same institution), and two zoologists (not connected with the same institution), whose expenses shall be paid, but who shall receive no pay for their advice. These may, however, be employed by the Board in other work.

Resolved, That while the State Geologist shall still continue to be the executive officer of this Board, it will make no permanent appointment and no permanent contract for scientific work without consultation with the scientific advisers immediately interested, and accordingly while the State Geologist shall conduct the preliminary negotiations he shall present the proposed contract or appointment to the Board with the written endorsement or opinion of the two advisers most interested, and he shall also report to them all temporary appointments and provisional arrangements, which as heretofore he is authorized to continue until the Board and advisers have had a chance to pass upon them.

Resolved, That at the stated meeting of this Board in March, or at such adjourned meeting thereof as may be duly called for the purpose, the official scientific advisers of the Board be authorized, expected and requested to meet with it to advise with regard to the work of the following summer, the expenses of the ensuing year, and any other matters that they may see fit. At such meeting the State Geologist shall be present, with estimates prepared.

Resolved, That in the first instances the heads of the geological departments at Houghton and Ann Arbor be requested to be or to nominate the geological advisers, while the council of the Michigan Academy of Sciences nominate the other four.

WORK IN HAND.

The following is the state of the work in hand:

A paper on the Ecology of Isle Royale and the Porcupines by C. C. Adams is in the printer's hands.

W. F. Cooper's report on Bay county still awaits publication. The economic chapter has been printed in the Michigan Miner.

C. A. Davis' papers on the distribution of the peat producing plants has been handed in, but returned for revision and to keep up to date, as the printer is not ready for it.

The manuscript of W. M. Gregory's report on Arenac county has been partially handed in.

The report of W. H. Sherzer is still awaiting the topographic base which is, however, now practically complete, for the Detroit, Wyandotte, and Romulus sheets of the joint topographic survey and the four sheets into which the Wayne quadrangle has been divided, Dexter, Ann Arbor, Saline, and Ypsilanti will soon be issued.

Dr. W. C. Gordon is preparing his report on the Black River section. Mr. F. E. Wright made a short trip to Mt. Bohemia this fall to visit it before writing up his final paper.

Copy for the nine-sheet map of the surface geology of the State, on a scale of six miles to the inch, is nearly ready for four of the sheets. During the summer Prof. Russell covered what territory of another sheet lies within our borders, that around Wisconsin. Frank Leverett of the U. S. Geological Survey, assisted at various times by W. C. Gordon, G. L. Tower, and C. A. Davis on behalf of the State, covered another sheet. I hope to begin publication of this map this winter.

Incidental to this work Frank Leverett prepared a report on the flowing wells of the district covered by him,[1] which supplements my 1903 report in a partial way. The flowing wells of the Lake Michigan shore deserve greater attention and advertising than they receive. The whole shore from the Garden peninsula to Drummond Island has the physical attractions that have made Mackinaw favored for years. It is separated from the torrid breezes from the south by cool waters; and sparkling "fountains" should furnish uncontaminated water, and eliminate typhoid, that bane to summer resorts which so often have makeshift sanitary arrangements.

CO-OPERATION.

Referring to previous reports regarding co-operation and their policy regarding the same, I merely give an account of what has been done so that those who wish to keep track of the progress of investigation may know where to look. I do not try to assign or claim exact credit. In some cases as in the book on Michigan Rocks and Minerals the assistance is almost wholly from our already published material, or that acquired by the authors when members of this survey.

In other cases, as in stream gauging, simply advice and casual assistance, like the occasional detail of a man paid by the U. S. G. S. has been lent, while in others financial support and unpublished material has been turned over.

[1] U. S. Geological Survey Water Supply paper No. 160.

U. S. GEOLOGICAL SURVEY.

Hydrographic division. Mr. Frank Leverett has compiled an extensive report on the surface waters and shallower wells of the Lower Peninsula, practically to take the place of my U. S. Water-Supply paper No. 30,—now long out of print and *scarce*. All our material in that line was put in his hands, and his report is now in the hands of the editor. We have, as mentioned, furnished him assistance in the Upper Peninsula. But from him I think we received more than we gave.

In Water-Supply and Irrigation Paper No. 145, pp. 44-45 and 129 to 144, are papers regarding water problems in Michigan, the latter being similar to our first paper in our 1904 report by M. L. Fuller.

Water-Supply and Irrigation Paper No. 149, pp. 65-69, contains a list of deep borings in Michigan largely compiled from us.

The records of flows and gaugings are contained in Water-Supply and Irrigation Papers

49, pp. 243-259, 1900.
75, pp. 110-113, 1901.
83, pp. 285-288, 1902.
97, pp. 431-498, 1903.
129, pp. 17-67, 1904.
See also pp. 294-296.
See 22nd annual report, part 4, p. 261.

Water-Supply and Irrigation Paper No. 102, pp. 489-512 contains data similar to Cooper's paper in our annual for 1903. Water-Supply and Irrigation Paper No. 114, pp. 242-247 is practically a summary of my W.-S. & I. P. No. 30, out of print. I looked over the proof. It has a geological sketch map of the Lower Peninsula.

In connection with the collection of deep well records we have been collecting and dividing samples from Ypsilanti, Adrian, St. Joseph, and other points.

TOPOGRAPHIC SURVEY.

The condition of the joint topographic survey at the beginning of the year was given in the following statement by the United States Geological Survey:

By the terms of an agreement entered into between the Director of the United States Geological Survey and the State Geologist of Michigan, dated August 17, 1901, the sum of $2,000 was allotted by the State, and the Director of the United States Geological Survey made an allotment of $4,000 for the co-operative topographic survey of Michigan during 1901 and 1902. Under the terms of an agreement signed May 27, 1903, provision was made for the expenditure of $1,700 by the State, and $2,500 by the Federal Survey for the government fiscal year ending June 30, 1904. By agreement signed May 25, 1904, the State allotted $1,000 and the Federal Survey $3,200, for the fiscal year ending June 30, 1905. The total expenditure in co-operation by both the State and Federal governments on this survey to date has been $14,400.

Prior to co-operation the survey of seven quadrangles was completed, covering 963 square miles within the limits of the State, and atlas sheets representing these have been published by the United States Geological Survey. These are: Crystal Falls, Iron River (Mich.-Wis.), Maumee Bay (Ohio-Mich.), Menominee Special (Wis.-Mich.), Sagola, Toledo (Ohio-Mich.), and Whitbeck. Three others covering 422 square miles within the State were compiled; namely, Ned Lake, Passage Island, and Perch Lake. The survey of two special districts, Gogebic Iron Range (Wis.-Mich.), and the Marquette Iron Range, covering 194 square miles within the borders of the State was also completed.[1]

[1] This mapping was done in connection with studies of the iron ranges and was not found to be satisfactorily accurate.

The result of co-operation to the close of 1904 is a complete map of 1,687 square miles represented on the Dexter, South Lyon, Saline, Ypsilanti, Grosse Point, Detroit, Wayne, Wyandotte, and Romulus atlas sheets. Of these the Ann Arbor sheet, a two-mile reduction of the first four, has been published. Including work done by the United States Geological Survey alone previous to co-operation, the mapping of 3,266 square miles within the borders of the State has been completed.

The results of the above mapping are being published at the expense of the United States Geological Survey. Each atlas sheet is approximately 16½ by 20 inches.[1] Differences of elevation are shown by contour lines. The sheets are engraved on copper and are printed from stone in three colors; black for all artificial features, as roads, railways, houses, etc.; blue for all water features, as lakes, rivers, etc.; and brown for contour lines representing the surface relief, or the shapes of slopes of hills, valleys, etc.

The published sheets are sold at five cents each, or $3.00 per hundred.

During the year the Wayne and Grosse Point sheets have been published, the latter including Belle Isle and the Detroit Water Works. The other maps have been held a short time to incorporate some recent detailed surveys of the Huron river, but a number should be out this winter.

The balance of the appropriation of 1904-5 was spent in revising the work along Detroit river and starting work near Marquette. For various reasons I requested that a quadrangle near Marquette, which was largely water, be surveyed. It seemed that the Upper Peninsula should share in the work. No more fitting place could be found than the neighborhood of the Normal School, for the teachers and pupils would then have the advantage of a good local map in studying geography. The area required to complete a sheet was comparatively small, and the primary triangulation already done. Finally by completion of this sample we could have something upon which to base estimates of the cost and value of such work in that region.

I enclose extracts from correspondence concerning the same from which it will appear that the cost has been unexpectedly high.

September 18, 1905.

It seems that we have gotten into real trouble in the Marquette region, in so far as the work has proven to be the most difficult and expensive that we have encountered anywhere. Mr. Sutton and I have both every confidence in Mr. Whitman, who has had wide experience under the most adverse conditions of mapping in such regions, and Mr. Whitman finds it impossible to make more than half the mileage we have made in the worst of the Adirondacks and the Maine woods. In consequence the work will cost considerably more than estimated, and to complete the Marquette sheet will take quite a little of the $1,250 which we had allotted for topographic work in the Pontiac region and neighborhood. In that region we are now completing all the primary control which you and I planned, and I doubt that we will do much topographic work.

Very respectfully,

(Signed) H. M. WILSON, Geographer.

November 18, 1905.

I am informed by Mr. J. M. Whitman, assistant topographer, that on behalf of the Cleveland Cliffs Iron Co. of Ishpeming, Michigan, you requested of Mr. Whitman an estimate of the cost of making a topographic map, scale about 2,000 feet to the inch, of the iron range in Marquette county, Mich., with a view to your offering co-operation towards the making of such surveys.

As the results of this past season's experience on the Marquette sheet, we find that in this particular region it will be as cheap to make a survey on a larger scale of 1:24,000 as on the smaller scale heretofore employed in that region by us, of 1:62,500. The cost of mapping the Marquette sheet was about double that of the most expensive work heretofore surveyed by us under like conditions; namely, $55.91 per square mile. I believe that we can safely estimate on the mapping of the area which you have in mind as costing about $55.00 per square mile for topography, but there will be the additional cost

[1] About 320 square miles.

for primary triangulation which is lacking in that region, so that the total expense will be about $60 per square mile.

I believe that the Survey would be willing to accept an offer of co-operation in doing this map work providing the area of survey in such an expensive region were limited. In this case I understand that the area is about forty by eight miles.

Very respectfully,

(Signed) H. M. WILSON, Geographer.

December 20, 1905.

I have the honor to make the following preliminary report of the co-operative topographic survey of the State of Michigan for the year 1905-6:

ALLOTMENTS.

Senate Bill No. 148[1] of the Legislature of Michigan, authorized the Board of Geological Survey of the State to coöperate with the United States Geological Survey for the making of a topographic map of the State, and appropriated $2,000 for the year ending June 30, 1906, for the prosecution of this survey, providing the United States Geological Survey expended an equal amount on the same work. On behalf of the federal bureau I allotted a like sum.

This work was prosecuted under an agreement signed by the Acting Director of this Survey June 20, 1905, and by you June 28, 1905, in which it was agreed to extend the terms of the agreement of May 27, 1903, to cover coöperation for the fiscal year ending June 30, 1906.

RESULTS.

In correspondence between yourself and Mr. H. M. Wilson, Geographer, of this Survey, under dates of June 28 and 29, 1905, plans were made for the prosecution of this work, and such plans have been carried out so far as the funds available would permit.

From the expenditure of the money provided for this cooperation a complete and accurate map has been made for publication on a scale of 1:62,500, with a contour interval of 20 feet, of 47 square miles of the area of the State, which represents the completion of the Marquette sheet, lying in Marquette county. During this mapping 70 trigonometric points were located; there were run 110 miles of spirit levels, in the course of which 788 elevations and nine permanent bench marks were established. There were also run 374 linear miles of road traverse, every bend and every house being accurately located. The topography of this region is probably the most intricate and detailed which the Survey has ever mapped. As a result the time required and the cost were exceptionally high. The resulting map is so intricate that a small edition will be published on the large scale of 2,000 feet to one inch, in order that all the results procured by this Survey may be legible.

In addition to the above considerable preliminary control was run on the Pontiac quadrangle, in Oakland county, resulting in 79 miles of spirit levels, in the course of which 468 elevations and 15 permanent bench marks were established. There were also run 322 linear miles of road traverse.

A large portion of the available funds were devoted to extending primary control for future mapping. Such control was extended over five 15-minute quadrangles, situated in Lapeer, Oakland and Livingston counties. There are the Howell, Highland, Pontiac, Rochester and Orion quadrangles. In the course of this survey 202 miles of primary traverse were run; 17 azimuths were observed and 18 metal tablets were set to mark the geodetic coordinates, all of which will be computed.

The total expenditure upon this work to date has been $3,810. The balance, $190, will be expended by the first of January upon completing the office drafting and computing the results.

Very respectfully,

(Signed) CHAS. D. WALCOTT, Director.

I shall not make any further recommendation regarding Upper Peninsula work, until the Marquette sheet has been issued and we have studied it critically, and have had time to determine its relative value, and the value of the methods of work compared with others.[2]

[1] Act No. 251.

[2] Since presentation of this report, use of this map by myself and reports by others indicate the value of the map, and that it is incomparably more accurate than, for instance, those published with the Marquette Monograph.

It seems to me hardly fair to recommend work in so much greater detail than that used in the other parts of the State, unless the large property owners of the country to be covered bear the extra expense involved.

DEPARTMENT OF AGRICULTURE.

I submit also extracts from letters from the department of agriculture regarding cooperation. I have mentioned above that they have mapped areas around Allegan county, Owosso, Pontiac, Bay City and Saginaw, Alma, and Munising, which can doubtless be obtained from congressmen.

December 12, 1905.

In reply to your letter of December 8th I would say that we shall be glad to furnish you with 20 copies of the advance sheets of each Michigan area as the reports are published.

In regard to coöperation, it has been our custom and it is our desire in every case where information or advice is furnished us by any of the State organizations to give this fact full recognition in the text and also in the titles placed upon the maps, since these form a portion of each report. It is very probable that during the progress of our work in Michigan we shall desire to call on you for information, not only as we have been able to do in the past, but also to a greater degree in the future, and it will probably be no more than fair recognition of the services which you have rendered and can render to place your name and that of your organization on the maps, as I suggested in a previous letter.

Very truly,

(Signed) MILTON WHITNEY, Chief of Bureau.

December 18, 1905.

I have just received your letter of December 15th, in regard to the work which your organization is doing in Michigan. As you say, we do not usually find that a geological map constitutes a detailed soil map. Nevertheless, the relationships between the soils and the geology of any region are so close that the broad classification of the soils follows quite closely after the geological classification, even though certain details may be different. For example, soil series as we are establishing them generally follow the geological classification, and the soil types constitute additional subdivisions of the geological formations.

We shall be very glad to receive copies of the various sheets of your nine-sheet map as they are issued. They will be of considerable value to us in locating and carrying on our soil survey work in Michigan. We would probably not need more than a few copies for office use.

You can be of great aid to us, through your maps and your detailed knowledge of the geology of Michigan, and while we shall make maps of one sort and you maps of another, the relation between the two kinds of maps will be such that a thorough understanding of the similarity and the differences which exist will be of help to both of us. I am glad to get your note in regard to the presence of finely ground limestone in the glacial material of the southern peninsula.

Copies of our maps will be forwarded you as rapidly as they are published, and any parties placed in the State of Michigan will be referred to your office for whatever information you may be prepared to give. In case we can serve you in any way we shall take pleasure in doing so.

Very truly,

(Signed) MILTON WHITNEY, Chief of Bureau.

Our close relations with the State institutions continue. For instance the examination of the cross section of the Tamarack Mine below the Calumet conglomerate was accomplished jointly by Pres. McNair of the College of Mines and Mr. Corey of the geological faculty and myself and W. C. Gordon. We have had necessary analyses made by Mr. F. K. Ovitz at the University of Michigan and Mr. F. B. Wilson of the College of Mines.

The following is a statement of the persons employed or under contract to furnish work during 1905, and a brief statement of their occupation.

PERMANENT STAFF.

A. C. Lane, State Geologist, executive duties, consultation regarding deep wells (St. Joseph, Benton Harbor, Adrian, Alpena, etc.), and drill core records (Arcadian, Franklin, Tecumseh, C. & H., etc.), editing reports, field work in the copper country, water reports for Leverett and Battle Creek, studies on mine waters, and brines.

W. C. Gordon. Charge of Houghton office. Preparation of Black river report, assistance in examining Tamarack Mine sections, Arcadian drill cores, and contour map near Hermansville.

W. F. Cooper. Work on Bay county report, on deep well records around Wayne county with W. H. Sherzer, watching rock salt shaft near Detroit, etc.

Harry R. Wight, clerk. Taking letters, 1451, 1904-5, 592 to December 16, 1905, typewriting manuscript, shipping reports, reading well temperatures, etc.

The above is the permanent staff. The following gentlemen of special qualifications have been employed on contract:

Prof. I. C. Russell of Ann Arbor. A report on the surface geology of the sheet of the nine-sheet map of the State that includes Iron Mountain (spending the summer in the region).

Prof. C. A. Davis. A report on the distribution and ecology of the peat producing flora (spending the summer in the Upper Peninsula).

Prof. A. W. Grabau. A report on the fossils of the Traverse limestone, (so extensively quarried near Alpena and Petoskey).

Prof. W. H. Sherzer. A report on Wayne county.

Prof. W. M. Gregory. A report on Arenac county.

Prof. T. L. Hankinson has also been kind enough to do some fish collecting on Keweenaw Point.

The following assistants were employed temporarily:

F. P. Frapwell, with Prof. I. C. Russell.

G. L. Tower, with F. Leverett.

This does not include chemical analyses paid for as such or unskilled labor by the day.

The following were employed by the United States on the joint topographic survey:

J. M. Whitman, topographer in charge.

J. N. Williamson, levelman.

B. L. Sherman, C. A. Blanchard, Frank Gennell, Edward Gilbert, E. C. Garwin, H. M. Gillman, H. W. Peabody, W. H. S. Morey.

Even for temporary positions on the joint topographic survey it is necessary to file applications at Washington with letters of recommendation, which of course I am glad to give to properly qualified persons, especially graduates or advanced students of engineering in our State institutions but there are two important conditions to be noted. The applicant must be over 20 years of age and must promise to stay through the field season. The latter condition can often be arranged with the engineering faculties. For permanent positions, one must pass the Civil Service examinations.

THE OUTLOOK.

The first fruits of the biological survey—a practical report on Isle Royale and the Porcupines—is in the printer's hands. Next should follow Cooper's report on Bay county and Bradford's account of the flora of the same, and perhaps some of the sheets of the nine-sheet map of the surface geology of the State. Next perhaps will be Davis' report on the peat producing plants, Gregory's report on Arenac county, a report tendered us by C. H. Kauffman on the fleshy fungi (mushrooms) of the State, Davis' report on Tuscola county, Grabau's report on the Traverse limestones, Sherzer's report on Wayne county, will come in an exact precedence, which cannot now be decided. This annual report and the reprinting the Douglass Houghton reports must come in when they will cause no delay. A report on various recent investigations in the copper bearing rocks, and mine waters and other waters of the State, and on the prospects for oil, could be rushed through rather soon if there were any reasonable chance of prompt publication. Under the circumstances it seems well to keep them open for new material as long as we can.

Of course the results of work relative to deep wells and diamond drills belong first to those who do the work, and I can submit letters as to the value of our work this past year to those interested.

SCIENTIFIC NOTES.

Putting aside then work on the copper bearing rocks, and also notes on deep wells, whether for oil or water, for separate treatment, there are miscellaneous observations worth making a matter of record on subjects which may not have extended treatment for some time.

MAMMOTH AND MASTODON.

According to the Muskegon papers a skull with teeth and tusks, the skull measuring three feet eight inches was found on the place of C. L. McKay, two miles north of Moorlands.

On Oct. 25, 1905,[1] Joseph St. Johns "digging a drain on the land of Chas. Warren, a short distance from Bancroft, found the skeleton of a mastodon. While the bones were not in the best state of preservation he found the ribs, tusk, teeth and many other bones. One tooth measures $4\frac{1}{4}$ x $3\frac{1}{2}$ inches in size and weighs one and one-quarter pounds, the tusk measures 54 inches in length and measures 18 inches around at the large end. The bones were about four feet under ground imbedded in marl."

Prof. Walter B. Barrows also acquired for the Agricultural College the lower jaw of a mammoth (a young female probably) found near Grand river, two miles below Eaton Rapids. As it was in quite fair condition it was worth about $10.00. Mr. James Lucas, of the National Museum of Washington, issues a circular regarding the collection and valuation of such bones.

[1] Detroit News. I visited Bancroft and verified the item. They were found near the line between Sections 36 and 25, T. 6 N., R. 5 E., the section being two feet of muck, six inches of shell marl, then sand. The bones in the marl are much better preserved.—L.

STRONTIUM.

Strontium salts have a value in beet sugar manufacture and in making red fire. Prof. E. H. Kraus, newly appointed to the chair of Mineralogy at the University, has been studying the distribution of the strontium sulphate and sulphide[1] largely out of the State but also in Monroe county where it was described by Sherzer in the Monroe county report.[2] I think it worth while to call attention to the presence of strontium in the waters of Lake Superior as well as many of our mineral waters,[3] and particularly to the fact that Dr. Kraus attributes to the presence of celestite the "acicular," "vermicular" or "gashed" appearance of many dolomites. This appearance is, I may say personally, almost characteristic of certain dolomites of the Monroe (neontaric) group. It is therefore well to keep an eye out for accumulations of celestite which is accumulated in commercial quantities in the famous caves of Put-in-Bay, and also occurs in some of the Monroe quarries quite abundantly. It cleaves well, like calcite, but the cleavages are not equally good. It is heavier and often bluish, and may occur north of St. Ignace or on the islands north of Beaver Island.

In the 1904 report were given Ovitz's figures of analysis of the water of Swan Creek, Grosse Isle. The following is combined from the original figures, to correspond to the analysis given below and to the crystals found in a dried drop of the water.

SWAN WELL, GROSSE ISLE.

	Parts per million. Grams per metric ton.
$NaCl$	30.7
KCl	20.2
Na_2CO_3	25.5
$CaCO_3$	213.2
$CaSO_4$	1,559.7
$SrSO_4$	66.6
$MgSO_4$	361.8
SiO_2	18.8
$FeCO_3$	2.0
	2,298.5
Excess CO_2 (bicarbonate)	40.6
Water of crystallization	45.6
Total solids on evaporation	2,384.7

With these it is interesting to compare the artesian water at Put-in-Bay island. Apparently the sulphates are leached downward, are reduced by organic matter to sulphides, and sometimes decompose to hydrogen sulphide or even to sulphur, as Kraus says.

[1] American Geologist, Vol. 35, pp. 167-171, March, 1905; also Bull. Geol. Soc. America; American Jour. Science, July, 1904, Vols. 18, p. 30; 19, pp. 286-293, 1905; Science, Oct. 20, 1905, p. 502; Seventh Report Michigan Academy of Science; Z. fur K. XLII, Band 1, p. 1.

[2] Volume VII, part 1.

[3] Annual for 1904, p. 20; also Water Supply and Irrigation Paper No. 31.

PUT-IN-BAY ISLAND, OHIO. ANALYSIS OF VICTORY STRONTIA SPA WATER BY G. A. KIRCHMAIER, PH. C.

	Parts in 1,000,000.	Grains per U. S. Gal.
Strontium sulphate	579.00	33.755
Silica	2.50	.145
Iron	3.50	.204
Alumina	1.50	.087
Sodium chloride	19.20	1.119
Potassium chloride	15.60	.908
Magnesium carbonate	246.20	14.354
Calcium carbonate	440.60	25.690
Calcium sulphate	1,131.83	65.985
Total Solids	2,439.93	142.247

In this connection the following analyses may be of interest, which are of beds in the Woolmith quarry.

	1.	2.	3.	4.
Silica	1.77	1.30	0.58	20.14
Alumina Al_2O_3	0.01	0.16	0.37	.86
Ferric oxide (with ferrous)	.41	0.20		
Magnesia	20.84	19.79	18.11	15.32
Calcium oxide	29.65	31.14	25.18	19.56
Water—	0.12	0.18	.....	.....
Water+	0.48	0.57	.....	.....
Carbon dioxide	46.50	45.18	39.55	31.94
P_2O_5	tr.	tr.	.02	.....
SO_3	0.33	1.15	6.33	0.56
MnO	tr.	tr.	.....	.....
Organic matter with petroleum odor	pr.	pr.	.92	10.72
BaO	....	.....	.13	.07
SrO	....	.....	7.86	.66
Na_2O	....	.....	.11	.09
K_2O	....	.....	.05	.07
Cl	....	.....	.04	.03
H_2S	....	.....	tr.	.02

1. Is the tenth layer from the top. E. C. Sullivan.
2. Is the fifth layer from the top. E. C. Sullivan.
3. Is near the surface cover. Bed A. Dr. E. H. Kraus.
4. Is a porous, cavernous layer. Dr. E. H. Kraus.

It is notable how many constituents are found in analyses 3 and 4 not given in Nos. 1 and 2, presumably because not looked for, while 3 and 4 have their own gaps.

In Nos. 3 and 4 the molecular weights are for:

Calcium oxide	.4488	respectively	.3493
Magnesium oxide	.4487	respectively	.3795
	.8975		.7288
And for carbon dioxide	.89886		.7259

Showing how closely true dolomite they are. The barium and strontium are similarly combined with the sulphate.

BUILDING MATERIAL.

Limestone, clay, cement, etc. As usual numerous samples of clay come to me to test. They are generally the fine grained not sandy kind. Even if they are reported "free from lime"—like the extensive beds of S. F. Saxton near Traverse City, which are also reported free from grit on the low land, there is often a large percentage of limestone or dolomite flour. This though it will not burst brick, prevents it being hard burnt, and makes the brick generally light colored.[1] As I have previously said the depletion of lumber has meant growth of the brick industry, and plants have been established and enlarged, *e. g.* the Myerburg Terra Cotta & Brick Company, four miles south of Battle Creek; a factory at Twining; Britton . (See analyses below.)

I made an interesting visit to the plant of the White Portland Cement Co. at Four-mile Lake, near Ann Arbor. They were working close to Four-mile lake, which was drained, and using the kiln process, hoping thereby to save heat used in evaporating the slurry. They were using a clay which came directly beneath their bog lime (marl) rising in the bottom like a knoll. The section was;

1 to 2 feet, peat.
1½ to 2 feet, bog lime with a layer of Unio.
Shells on top of the clay.
10 feet, blue clay.

South and southwest from the lake there is a long extent of swamp with two to seven feet of peat underlain by bog lime (marl) which is said at times to run up to 99.87% $CaCO_3$. This island of blue clay is very tough. The cement is said to stand 900+ pounds per square inch on a 28-day test. But the plant at last accounts was in difficulties. We have also received from Mr. Berger blue prints of surveys near Lakelands and Ann Arbor. And the following analysis of the bog lime from Ore Lake received through Prof. I. C. Russell, may be compared with that from Zukey, Bass and Lime lakes of Volume VIII, Part 3.

ORE LAKE.

SiO_2	0.53
Al_2O_3	0.14
Fe O + Fe_2O_3	0.96
MgO	1.10
CaO	51.87
Na_2O	0.1
K_2O	0.1
H_2O-	0.97
H_2O+	1.22
CO_2	42.30
P_2O_5	0.06
SO_3	0.14

The calcium and magnesium oxides require 41.95% of CO_2, so that there is over 90% $CaCO_3$.

[1] To make paving vitrified brick the fluxing material should not be anything which is readily fluid like lime and iron silicates, but something like the alkaline alumo silicates which, as Day and Allen have shown, are so viscous as to retain their angular form even when melted.

Mr. J. J. Wirtz (Jan. 28, 1904) sent us some information regarding lakes with bog lime (marl) near St. Ignace and within one mile of Lake Michigan, as follows:

1. SiO_2 0.90%, $CaCO_3$ 98.06; over 140 acres, lime from 15 to 25 feet deep near the shore and bottom, over 30 feet down farther out at about 20 feet, three to four feet of peat, then marl again.

2. SiO_2 1.10, $CaCO_3$ 96.28; close to shore 10 or 12 feet, near center to 28 feet, the marl very hard and firm, no water under ice and no dirt on marl, at about 20 feet a peat layer then marl again.

3. SiO_2 1.90, $CaCO_3$ 89.15, sample dirty, being taken from the shore with a shovel.

This would seem to be a promising deposit. But on the whole the tendency seems to be to neglect the marl (bog-lime) deposits and investigate the limestone. The reason may be found in Wentz's statement that "the cost of fuel in the dry process using rock" (limestone) "and shale is about 20 to 24 cents per barrel under normal conditions, but from 40 to 60 cents per barrel in the marl or slurry process."

For example the Standard Portland Cement Co. has been turning to Charlevoix, bringing it in line with the Elk Cement and Lime Co., which has practically moved to Petoskey as its base of supplies. This company originally looked up the Lakelands deposits then carefully examined Upper Herring lake and Little Platte lake in Benzie county and have given me a blue print of their soundings there which may sometime give us some idea of the rate of growth of such deposit of bog- or Chara-lime.

Analyses of the Herring lake deposits are as follows:

December 12, 1904. Upper Herring lake, Benzie county, Blaine township. Analyses of marl.

	1.	2.
Silica	10.15	14.92
Oxide of iron	.59	.77
Alumina	3.90	4.21
Lime	41.75	38.21
Magnesia	2.45	2.98
Carbon dioxide	35.51	33.32
Organic matter	5.65	5.59
Total	100.00	100.00

	3.	4.	5.	6.	Average of 8 samples.
Silica	1.92	17.74	19.43	29.40	1.70
Oxide of iron	1.42	1.33	1.33	1.45	1.00
Carbonate of lime	89.62	64.40	61.30	53.26	88.94
Alumina	.....	3.62	4.48	4.63	*
Carbonate of magnesia	2.45	5.79	6.96	7.95	none
Organic matter	4.59	7.12	6.50	3.31	8.36
Total	100.00	100.00	100.00	100.00	100.00

The deposits of marl and clay around Little Platte lake are shown by analyses by W. H. Simmons, the Bronson chemist,[1] given below. Note

* Combined with iron oxide.

[1] See also pages 297, 323 and 333 of Volume VIII, part 3.

especially the percentage of organic matter in the marls which does not hurt the finished cement but lowers the capacity of the plant. They are low in magnesia.

In the analyses of the surface clays, note the presence of variable amounts of magnesia, which is, however, low in No. 544 and 552, and 553. Nos. 592 to 595 already printed, are more nearly the common type.[1] Some of the clays, for instance No. 579, might be valuable clays for front and paving brick. The condition and amount of volatile matter would need examination.

Letters of F. H. Aldrich, Nov. 11, 1903, and Dec. 2, 1904. Clays found near Platte lake, Benzie county.

Report of analyses. Bed "A." Sample clay. Laboratory No. 579. Mark 48 W. J. G. Date of receipt, 10:30: 1900. Composition:

	579.	544.	552.	553.
Silica	58.02	57.58	62.14	57.00
Alumina	17.98	17.10	19.11	17.96
Iron oxide (Ferric)	4.02	5.23	6.44	6.04
Oxide of calcium	1.53	2.81	.14	3.94
Oxide of magnesium	1.37	.72	.96	2.43
Sulphuric acid (Anhydrid)	trace	.34	.17	2.43
Volatile matter	13.04	12.60	8.35	.34
Alkalies by diff	3.82	.....	3.33	.....

Sample marl. Laboratory No. 525. Mark 1. Date of receipt, 7:28: 1900. Composition:

		16.	17.	18.
Silica	4.34	3.56	2.52	3.25
Alumina, Iron oxide (Ferric)	1.58	.45	.51	.83
Carbonate of calcium	85.11	77.46	84.01	77.95
Carbonate of magnesium	.95	No trace	trace	trace
Sulphuric acid (Anhydrid)	trace	.58	.73	1.11
Organic matter	7.00	16.42	11.04	.....
	99.08			

Small amount of sand reported with silica.

Report of analysis. Samples marl. Laboratory Nos. 530, 531, 532. Mark, 10, 3, 4. Date of receipt, 7-28, 1900. Composition:

	10.	3.	4.
Silica	5.15	7.35	3.18
Alumina, Iron oxide (Ferric)	.48	1.07	1.10
Carbonate of calcium	86.43	82.19	79.17
Carbonate of magnesium	.73	.35	.19
Sulphuric acid (Anhydrid)	.55	.68	.85
Organic matter	6.50	8.00	15.00
	99.84	99.64	99.49

Respectfully submitted,

(Signed) W. H. SIMMONS.

Bronson, Mich., 8-12, 1900.

[1] Page 327 of Volume VIII, part 3.

Extracts from report on the property of the Standard Portland Cement Co., Charlevoix, Michigan, by the Robt. F. Wentz Engineering Company.

Toronto, Ont., May 23, 1904.

Standard Portland Cement Co., 812 Hammond Building, Detroit, Michigan.

Gentlemen: I herewith respectfully submit my report of the examinations of the various properties owned by you. The limestones properties are located west of the city of Charlevoix, in Charlevoix county, Michigan. The shale deposit is located near the village of Ellsworth, in Antrim county, about 10 miles south of the city of Charlevoix, and along the tracks of the Pere Marquette railroad. The proposed mill site is located on the west end of Pine lake, about one mile south of Charlevoix. From the above named properties we have selected a number of samples for analysis.

The result of the examination of these properties, raw materials and their locations, as herein briefly set forth, is conclusive evidence that a cement plant located on the proposed site will have many natural advantages.

PROPERTY AND RAW MATERIAL.

The limestone and cement rock deposits are situated one mile west of the city limits, and are bounded on the north by Lake Michigan.

The deposit consists of about 435 acres, at an elevation from 20 feet to 40 feet above lake level, and is composed of strata of limestone and cement rock of different and distinct chemical proportions, averaging from four feet to six feet in thickness. The different strata are remarkably uniform in composition, free from deleterious ingredients, practically inexhaustible, and extending to a known depth of several hundred feet. A large portion of the rock is exposed on the surface, some parts are covered with an overburden of 12 inches to 18 inches of earth and gravel. Because of these favorable conditions, the quarrying can be accomplished at a minimum cost.

Many of the limestones in the northern part of the Lower Peninsula contain a high percentage of magnesia; some have inter-stratifications of magnesian limestone, and still others have pockets of magnesian limestone. Such limestone deposits used for the manufacture of Portland cement cause a great deal of trouble and involve large expense in selecting and separating them in the quarry. Your deposit is free from all the above named unfavorable conditions. Every sample that we selected and analyzed shows but a small per cent of magnesia.

The upper stratum is composed of a soft, crystalline, light colored limestone, which is easily crushed and pulverized. The second stratum is composed of a soft cement rock.

The shale deposit, as stated above, is located along the line of the Pere Marquette, about 10 miles south of the proposed mill site. This shale is most admirably adapted for the manufacture of Portland cement. It is very soft, free from grit, and contains but a small amount of moisture; it is accessible and can be quarried and prepared for the kiln at the lowest possible cost. The proportions of silica and alumina in the shale are also very good. This shale, used in connection with the limestone, will make a mixture from which the highest grade of Portland cement can be produced.

* * * * * * * * * *

The analyses of their material, the limestone,[1] from the Traverse beds,

[1] Report of Robt. F. Wentz, and letters Dec. 7, 1904.

one mile west of the city limits of Charlevoix, Michigan, are like numerous analyses from this horizon previously given. No. 2 is rather high in magnesia, and as I have before remarked, the coralline parts of the Traverse are the freer from magnesia. The Traverse formation is *not* altogether free from magnesian bands. Analyses of shale[1] from near the village of Ellsworth, Antrim county, must be weathered Antrim shale. I question if they would remain so low in organic matter to any great depth, and that would have to be considered in time. See the shale analyses 7 and 8.[2]

However, a stratum of shale, such as so commonly occurs in the Traverse, and is quite suitable for cement, has been found only fifteen feet from the surface near the limestone quarry and may be used.

ANALYSES OF LIMESTONE.

December 12, 1904.

Samples taken about one mile west of the city limits of Charlevoix, Mich.

	1.	2.	3.	4.	5.
Carbonate of lime ($CaCO_3$)	96.10	91.34	95.70	95.08	93.88
Carbonate of magnesia ($MgCO_3$)	1.20	4.62	1.60	0.96	1.52
Silica (SiO_2)	1.40	0.92	1.00	1.38	2.45
Oxide of iron and alumina	0.80	1.06	0.80	1.02	0.95
Sulphuric anhydride	trace	.....	trace	trace	trace
Organic matter, etc	0.50	2.06	0.90	1.56	1.20
Totals	100.00	100.00	100.00	100.00	100.00

From prospectus.	6.	7.	8.	9.
Oxide of iron and alumina	1.50	1.21	2.40	2.73
Carbonate of lime	95.64	96.03	87.86	87.42
Carbonate of magnesia	none	none	none	none
Silica	1.54	1.93	5.74	6.11
Sulphuric acid	.53	.40	.72	.69
Organic matter	.47	.36	2.98	2.73
Moisture by difference	.22	.07	.30	.32
Totals	100.00	100.00	100.00	100.00

[1] Page 561.

[2] Also an analysis of the Antrim shale from a well made for Francis H. Cloud yielded:

Moisture	1.21 per cent
Volatile hydrocarbon	16.34
Fixed C	5.55
Ash	77.55

The ash was mainly clay, some pyrite, no limestone.—L.

ANALYSES OF SHALE.

December 12, 1904.

Samples of shale taken near the village of Ellsworth, Antrim county.

	1.	2.	3.	4.	5.
Silica (SiO_2)	50.44	52.36	52.00	58.20	59.94
Alumina (Al_2O_3)	18.96	31.40	21.01	18.28	18.03
Oxide of iron (Fe_2O_3)	6.28	6.44	4.73	2.58	2.40
Lime (CaO)	4.69	3.36	4.72	2.63	2.82
Magnesia (MgO)	3.85	4.34	6.73	none	none
Carbon dioxide (CO_2)	6.36	5.61	3.05	11.72	10.53
Sulphuric anhydride (SO_3)	0.92	0.06	1.44	.73	.56
Moisture	4.08	3.28	2.60	2.12	2.28
Organic matter	4.42	3.15	3.72	3.74	3.44
Totals	100.00	100.00	100.00	100.00	100.00

	6.[1]	7.[1]	8.[1]
Silica	52.36	58.20	69.95
Alumina	21.40	18.20	9.26
Oxide of iron	6.44	2.58	2.71
Lime (CaO)	3.36	2.63	0.61
Magnesia (MgO)	3.85	2.24	1.03
Carbon dioxide	5.61	3.74	2.12
Moisture, organic matter and difference	6.98	13.33	14.32
Totals	100.00	100.00	100.00

The analyses of shale from prospectus and secretary and from Mr. Wentz show some errors in copying figures and I understand the originals were lost in moving office, so I give both sets. No. 1 appears to be correct. No. 2 is a more complete form of No. 6 with a typewriter's slip in the alumina evidently. Nos. 4 and 7 may be from the same original.

Mr. A. N. Clark of the Wallaceburg Sugar Co., gives the following analysis of the Amherstburg quarry, just across Detroit river from the Sibley and the same formation geologically.[2]

DUNDEE LIMESTONE AT AMHERSTBURG.

Calcium carbonate	98.50
Alumina and iron oxide	0.20
Magnesium carbonate	0.73
Silica	0.56
SiO_2	faint trace
P_2O_5	faint trace
BaO and SrO	none

We also owe to Mr. J. G. Dean, of Ottawa, the following analyses: (1) a surface clay near Saginaw with about one-quarter limestone flour as usual; (2) a surface clay exposed by the Au Sable river, probably leached and

[1] From Wentz.
[2] See annual 1903, p. 175.

superficial; (3) a clay of the Britton Pressed Brick Co. Note Mr. Dean's comments. (4) From the same horizon as the Bellevue limestone (Annual for 1903, page 174) but much more magnesian.

It will be remembered that the Michigan Alkali Co., who used the Bellevue quarry for a while for cement have sold it.

July 5, 1905. Analysis of Saginaw clay.

Silica	51.81
Alumina Al_2O_3 ..... } Iron oxide Fe_2O_3.... }	11.02
Lime $CaCO_3$	23.08
Magnesia $MgCO_3$	5.91
Loss on ignition	6.62

July 5, 1905. Analysis of clay from Au Sable river.

Silica SiO_2	54.40
Alumina Al_2O_3	24.00
Iron oxide Fe_2O_3	7.16
Lime CaO	3.05
Magnesia MgO	1.75
Loss	6.80

NOTE.—This was taken near the surface, other samples taken farther down were so sandy and limey that they were not tested.

July 5, 1905. Analysis of the Britton clay of the Britton Pressed Brick Co., Britton, Michigan.

Silica SiO_2	67.80
Alumina Al_2O_3	14.17
Iron oxide Fe_2O_3	5.37
Lime CaO	2.16
Magnesia MgO	.88
Loss on ignition	6.60
Sulphuric anhydride SO_3	....

NOTE.—This is an extra fine pressed brick clay, possessing many fine features, especially for color.

July 5, 1905. Analysis of Parma Limestone.

Silica SiO_2	2.36
Alumina Al_2O_3	trace
Iron oxide Fe_2O_3	3.28
Lime CaO	41.18
Magnesia MgO	8.72
Loss	42.28

Iron oxide and alumina weighed together but only a trace of alumina was present.

The Parma limestone is from a limestone deposit about one mile northeast of the village of Parma on the M. C. R. R. probably 300 acres in extent.

J. G. DEAN, Analyst, Ottawa, Canada.

SAND LIME BRICK.

I have mentioned these brick in previous reports. The business seems to have a good hold in the copper country. Here three shades are made, according as the lime is mixed either with (a) Lake Superior sand which makes a very white brick; (b) felsitic conglomerate stamp sand, the Albany and Boston conglomerate No. 15, mined at the Franklin Junior Mine, which makes a pink brick; or (c) amygdaloid and trap stamp sand, giving a brick of a bluish hue.

The last class of brick will, I fear, not be very satisfactory (amygdaloid and trap crumble and slake on exposure to the weather). The other two will be quite satisfactory in endurance, as they are pleasing in appearance.

The L. S. Sand Brick Co. were turning out about 20,000 a day (Sept. 4, 1905), and the brick are said to stand a crushing stress of 5,000, 4,500, 4,375, pounds per square inch respectively. It will be remembered that S. V. Peppel[1] found that in spite of high porosity sand brick stood frost remarkably well, and Buckley[2] shows that the size of the pores was an important factor in resistance to frost.

The following item from the Detroit Free Press[3] is interesting, not only historically but also because it gives the locations of buildings made by this process many years ago. One objection to them among engineers and builders has been their newness, and their uncertainty as to the durability of the brick:

"It will surprise some people to learn that there are buildings in the upper peninsula of Michigan which were erected forty years ago and the material used was the sand-lime brick. These brick were manufactured at Marquette at a plant erected on the lake shore near Little Presque Isle. The factory was built by Cornelius Donkersley and S. P. Ely. The latter was vice-president of the old Marquette, Houghton & Ontonagon Railroad Co. and at the head of several mining companies. He was a great traveller and it was on one of his trips in Europe that he learned of the method of making brick from sand and lime. He visited Germany and investigated the process. Returning, the plant was erected and operated a number of years. The machinery was crude and only one brick at a time could be turned out. These brick were not steamed but were laid carefully in the sun to harden. In putting them in a building they had to be carried on a pallet. Today they are as hard as granite blocks. The brick were large and cumbersome, weighing as much as four ordinary brick. The expense of manufacturing them and the low price of timber resulted in the closing down of the plant. Among the buildings which are now standing are the Presbyterian church on the main street in Marquette, which was built thirty-nine years ago, and the round house of the old Marquette, Houghton & Ontonagon Railroad, now the Duluth, South Shore & Atlantic."[4]

ROAD METAL.

The establishment of a highway commissioner is quite a step in advance which I gladly welcome. Michigan is rich in good road metal, and with only a little more expense, and more care and intelligence can soon have a good system of roads which is already begun. The Keweenawan traps are in many cases very convenient to water transportation. Not infrequently they are already crushed in mining operations, although the rock close to the mineral lodes is naturally not always of the very best quality in resistance. But they have good cementing power.

The limestone quarries of the northern part of the State and Bay Port and

[1] Rock Products, Louisville, Ky., and pamphlets.
[2] Building Stones of Wisconsin, issued by Geol. Surv. of Wis.
[3] June 25, 1905.
[4] Also store of B. Neidhart, S. Front St. and the old library building on Spring St. See Clay Record, Dec. 30, 1905, p. 30.

Bellevue (and they might also be developed around Grand Rapids) make a road metal, not so hard, but tough and of good cementing powers, excellent under a finish coat of field stone spalls.

The boulders or "cobbles" of the fields show their hardness by having survived the glacial mill and ought at least to repay the cost of collecting them.

At my request, Mr. W. F. Cooper of our force collected certain samples for test by the U. S. Department of Agriculture, Division of Tests. The results are tabulated with some of the average results of the bureau for comparison below, and Mr. Cooper's notes on occurrence and those of the bureau on their quality, in quotation marks, with some comments of my own follow. The low per cent of wear, high hardness, and excellent cementing values with the exception of No. 1243 are notable.

The following letter is of interest:

WASHINGTON, D. C., January 6, 1904.

Mr. W. F. Cooper, Michigan Geological Survey, Lansing, Michigan:

DEAR SIR: I enclose the reports of tests, just completed, on your samples of rock. If the Michigan Geological Survey would care to have copies of all the tests we have made on samples from that State, we shall be glad to send them, as well as reports of all future tests.

I have had many inquiries from Chicago concerning trap rock for road building purposes. I understand that such rock occurs along the northern coast of Michigan. It would be profitable for anyone to supply Chicago with such rock, as the present price of granite per ton is $4.00.

Respectfully,

(Signed) LOGAN WALLER PAGE,
Chief of Division of Tests

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF PUBLIC ROADS, DIVISION OF TESTS.

1131. "Altered diabase from Tamarack No. 2 shaft, Calumet, Houghton Co., Michigan. A fairly hard and tough diabase, with high resistance to wear and fairly good cementing value. It is well adapted for highway and suburban traffic."

This shaft is connected with the Calumet conglomerate lode by long cross cuts traversing many melaphyre flows. From these cross cuts much of the road metal comes. It is thus quite a way from the lode and better in quality. It is what I call a melaphyre or ophite, composed mainly of augite and labradorite. See annuals for 1903 and 1904.

This road metal is widely used near Calumet and makes excellent roads. At the Whiting shaft of the Calumet and Hecla, which is similarly situated, all the rock not sent to the stamp mill for its value in copper is now put through crushers, and thus the accumulation of unsightly piles of waste rock is saved, while splendid macadamized roads are extending in all directions. Especially in connection with the new highway bounty law, this should be the most economical way of disposing of the waste rock.

1132. "An altered diabase from the Centennial mine, Calumet, Houghton county, Michigan. Rather soft diabase, with fair resistance to wear and good cementing value. Well suited for highway and country road traffic."

This was taken from the old dump of this mine on the Osceola lode, not the new workings. It is also a melaphyre. Its inferior hardness is probably in part original, being nearer the mineralized lode and more decomposed. It had also been longer exposed to the weather, and was in that respect different from the Tamarack rock. This appears to have led to a hydration that made it less porous and heavier.

1133. "Hornblende schist from Marquette, Marquette Co., Mich. A very hard and tough schist, with fair resistance to wear and high cementing value. Well suited for highway and country road traffic."

In the city of Marquette, however, this material is said to wash rather badly on the hillsides; on the other hand is very dusty in summer. This might be remedied by using crude oil and a heavy steam roller.

This is from the Keewatin or greenstone schist the oldest known sedimentary formation.

1243. "Dolomitic sandstone from Grand Island, Alger Co., Mich. A fairly hard but not very tough rock with a low cementing value. Under the action of wet rolling the binding power can be increased to some extent."

This probably comes from the Calciferous or Lower Magnesian formation, and is not a desirable road metal, relative to those easily obtained nearby.

1287 and 1288. "Limestone from the Wallace Stone and Lime Co., Bay Port, Michigan. A hard, tough, dolomitic limestone which should make an excellent road material. It should be rolled wet if possible."

This is very widely and favorably known in making the stone roads of the Saginaw Valley. See Huron county report, Volume VII, part 2, where further tests are given. It was also mentioned in the annual for 1902.

Its age is that of the Maxville limestone (neo-Mississippian or Subcarboniferous) the same as that of Bellevue and Parma.

MAXIMUM, MINIMUM, AND AVERAGE RESULTS

Number of samples	Name.	Per cent of wear.			French coefficient of wear.			Hardness.		
		Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.
8	Amphibolite	4.7	1.5	2.6	26.7	8.5	18.3	18.1	18.1	18.1
28	Chert	27.9	2.7	11.0	14.6	1.4	5.4	18.8	18.3	18.6
27	Clay	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	Conglomerate	12.7	3.5	6.6	11.6	3.2	7.6	.....	.....	.....
96	Diabase	6.3	1.2	2.4	34.5	6.4	18.3	18.5	5.3	15.2
19	Diorite	4.0	1.6	2.8	20.6	10.0	14.6	16.8	15.5	16.2
37	Dolomite	18.6	2.4	5.6	16.9	2.2	8.4	14.5	4.3	7.8
1	Epidosite	3.6	3.6	3.6	11.2	11.2	11.2	18.0	18.0	18.0
11	Felsite	3.4	1.9	2.6	21.3	11.9	15.2	.....	.....	.....
1	Flint	7.2	7.2	7.2	5.5	5.5	5.5	.....	.....	.....
89	Field stone	10.3	2.1	4.1	19.2	4.6	10.9	.....	.....	.....
13	Gabbro	5.4	1.3	2.8	30.8	7.5	15.6	17.5	12.9	15.5
38	Gneiss	8.1	1.7	3.8	23.0	4.9	12.0	17.8	10.5	15.0
62	Granite	14.8	1.6	3.7	25.6	2.7	11.3	18.1	12.5	15.4
59	Gravel	.....	.....	.....	.....	.....	.....	.....	.....	.....
142	Limestone	34.2	2.1	6.0	19.0	1.2	8.6	16.0	−70.6	2.9
4	Marble	14.0	3.8	6.9	10.5	2.9	7.6	11.5	−4.8	3.4
5	Marl	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	Peridotite	4.3	3.6	4.0	11.1	9.3	9.9	11.6	11.6	11.6
29	Quartzite	4.7	1.6	2.9	24.5	8.5	15.1	18.2	12.6	16.3
11	Rhyolite	9.7	1.7	4.7	23.0	4.1	12.1	17.2	7.1	12.2
50	Sandstone	32.8	1.6	8.9	25.7	1.2	10.8	17.9	−130.0	−0.6
40	Schist	7.1	1.8	4.1	22.6	4.9	11.6	17.0	12.5	15.3
8	Shale	16.2	4.7	10.5	8.6	2.5	5.6	7.0	7.0	7.0
5	Slag	10.6	7.6	8.8	5.2	3.8	4.6	.....	.....	.....
9	Slate	6.9	2.6	5.0	15.2	5.8	6.9	15.8	−6.8	2.6
6	Syenite	3.2	1.9	2.6	21.0	12.6	16.1	16.5	16.5	16.5
1131	Altered diabase	.....	.....	1.96	.....	.....	20.41	.....	.....	12.5
1132	Altered diabase	.....	.....	4.16	.....	.....	9.62	.....	.....	5.3
1133	Hornblende schist	.....	.....	4.71	.....	.....	8.49	.....	.....	15.3
1243	Dolomitic sandstone	.....	.....	5.15	.....	.....	7.77	.....	.....	13.0
1287	Limestone	.....	.....	2.70	.....	.....	14.81	.....	.....	9.2
1288	Dolomitic limestone	.....	.....	.....	.....	.....	.....	.....	.....	9.5

PLASTER.

Naturally the gypsum business shares in the prosperity in building materials. The Acme Cement Plaster Co. has come to Grand Rapids and is reported to own 200 acres of plaster land. I am credibly informed that gypsum is found south of Grand Rapids convenient to mine.

PAINT.

An experienced paint man once told me that any material ground fine enough and mixed with good oil would make good paint. Reports of discoveries of paint materials are therefore not infrequent. Marl and the fine gritless clays which are so abundant are naturally ground and can be well used in this way. At times these clays are brilliantly ochreous from iron deposited by iron springs and in association with bog and iron ore.

The graphite slates of the upper Huronian which occur extensively in the Upper Peninsula in the upper Huronian or Animikie (neo-Huronian) are ground up into graphitic paint and can be used for foundry facings also. The

ON ROCK SAMPLES, CORRECTED TO JULY 15, 1905.

Toughness.			Weight per cubic foot.			Water absorbed.			Specific gravity.			Cementing value.					
												Dry grinding.			Wet grinding.		
Max.	Min.	Av.	Max. Lbs.	Min. Lbs.	Av. Lbs.	Max. Lbs.	Min. Lbs.	Av. Lbs.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.
9	9	9	193.4	187.1	190.2	0.62	0.04	0.32	3.1	2.9	3.1	36	3	9	73	11	31
21	11	16	184.4	124.7	155.9	11.1	0.46	2.34	3.0	2.0	2.5	36	1	11	106	5	27
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	500+	10	398	.....	.....	.....
.....	.....	.....	159.0	155.9	159.0	3.71	2.50	3.11	2.6	2.5	2.6	327	12	170	.....	.....	.....
54	4	26	199.6	162.2	184.0	2.73	0.04	0.32	3.2	2.6	3.0	301	2	32	500+	7	147
24	19	22	196.5	168.4	180.9	1.03	0.06	0.37	3.2	2 7	2.9	137	1	19	148	9	49
27	4	10	177.8	159.0	171.5	4.77	0.08	1.24	2.9	2.6	2.8	161	2	22	179	13	47
14	14	14	171.5	171.5	171.5	0.45	0.45	0.45	2.7	2.7	2.7	12	12	12	83	83	83
.....	.....	.....	174.6	159.0	165.3	3.13	0.02	0.84	2.8	2.5	2 7	101	2	34	.....	.....	.....
.....	.....	.....	162.2	162.2	162.2	0.20	0.20	0.20	2.6	2.6	2.6	31	31	31	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	46	5	17	16	16	16
22	10	16	193.4	171.5	187.1	0.71	0.04	0.26	3.1	2.8	3.0	131	1	23	.....	.....	.....
20	5	13	187.1	162.2	171.5	0.98	0.10	0.30	3.0	2.6	2.8	21	1	5	61	5.	32
22	4	11	187.1	155.9	165.3	1.59	0.04	0.30	3.0	2.5	2.7	77	1	8	53	6	21
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	500+	1	82	.....	.....	.....
20	3	9	193.4	131.0	165.3	13.22	0.03	1.31	3.1	2.1	2.7	231	2	35	500+	14	63
9	6	8	177.8	168.4	171.5	1.04	0.16	0.52	2.8	2.7	2.8	15	5	10	77	71	74
2	2	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	500+	55	323	.....	.....	.....
12	12	12	221.4	199.6	212.1	0.33	0.27	0.30	3.6	3.3	3.4	14	3	9	30	25	28
30	10	21	190.2	159.0	168.4	1.30	0.06	0.31	3.1	2.6	2.7	47	1	9	200	2	32
33	6	20	177.8	134.1	162.2	5.87	0.03	1.80	2.9	2.2	2.6	38	1	13	37	10	23
47	3	20	193.4	123.4	162.2	11.60	0.02	2.09	3.1	2.0	2.6	323	1	42	500+	12	98
34	6	24	199.6	165.3	184.0	1.19	0.06	0.37	3.2	2.7	3.0	127	1	19	232	11	55
3	3	3	171.5	155.9	165.3	4.84	0.87	2.39	2.7	2.5	2.7	500+	9	276	.....	.....	.....
.....	.....	.....	171.5	140.3	159.0	4.10	0.04	1.56	2.7	2.3	2.6	137	2	42	262	31	123
22	5	14	177.8	168.4	174.6	0.68	0.15	0.43	2.8	2.7	2.8	202	7	81	.....	.....	.....
10	10	10	187.1	168.4	174.6	0.40	0.10	0.22	3.0	2.7	2.8	11	2	6	27	20	24
.....	.....	18	.....	.....	174.64	.....	.....	1.235	.....	.....	2.81	.....	.....	.....	.....	.....	39
.....	.....	.....	.....	.....	180.87	.....	.....	.42	.....	.....	2.91	.....	.....	.....	.....	.....	55
.....	.....	30	.....	.....	182.43	.....	.....	.136	.....	.....	2.93	.....	.....	.....	.....	.....	127
.....	.....	7	.....	.....	159.0	.....	.....	.45	.....	.....	2.57	.....	.....	1	.....	.....	20
.....	.....	12	.....	.....	165.3	.....	.....	1.34	.....	.....	2.64	.....	.....	10	.....	.....	49
.....	.....	12	.....	.....	165.3	.....	.....	1.35	.....	.....	2.65	.....	.....	8	.....	.....	50

quantity thus required is not very large and could possibly be rapidly enlarged to meet an increased demand.

IRON ORE.

It is neither easy nor of general value to give an account of iron ore developments. Explorations are now in the hands of a few large companies, who either employ geologists all the time simply as such or hire the most eminent expert assistance, and generally employ engineers who have received first class geological training. The diamond drills are steadily at work making miles of records a month, and there is but little that the official geologist can do but gather up and coordinate the work of the various companies, so far as it may be accessible to him. I may refer also to the reports of the Commissioner of Mineral Statistics and the Monographs of the U. S. Geological Survey.

In a general way it may be said that there are two notable tendencies. The first is to open bodies of ore like Sec. 21 south of Ishpeming, formerly considered too low for work, but which are free from objectionable ingre-

dients like phosphorus and sulphur, and contain only fluxing ingredients like silica in addition to the iron.

A second tendency is to explore below the first found ore bodies finding other beneath. For instance in the Gogebic Range the ores lie in the ore bearing horizon but are generally bounded below by a dike. Under the dike comes a barren formation. Now it has been found at the South Colby and elsewhere that by persevering down another ore body which may not be conspicuous at the surface may be found resting on a still lower dike.

A sketch may make this clearer. Prof. Pumpelly tells me that the Newport Mine, in which he is largely interested, was never looking better than at 2,000 feet.

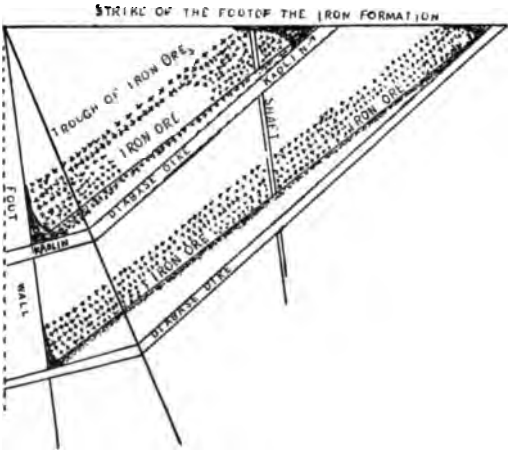

Figure 169. Illustrating the occurrence of iron ore on the Gogebic range.]

About 34 million tons came down from Lake Superior this year.

In view of the size and the ready accessibility of the iron ore deposits of Lake Superior it is safe to say that the bog ore deposits which are found in numerous places in both peninsulas, and generally run high in phosphorus are of no present commercial value. They sometimes run well up in manganese, but some of the Upper Peninsula iron ores are manganiferous, and sorted out for the manganese.

Sample of bog iron ore from C. L. Nelson.

Ferric oxide	21.24
Manganese calculated as Mn_2O_3	2½%

Balance of the material is silica and other insoluble substances.

COAL.

The production of coal has decreased this year, though the work of testing goes steadily on, spreading north from Bay City and also east and west from Saginaw. Within the limits marked out by geologists as the coal basin (see map) coal is not infrequently reported as also struck in drilling for water,[1] and is occasionally, but I believe always mistakenly, reported

[1] So at Flint, Detroit Times, Oct. 20, 1905; Shepard, Detroit News, Oct. 11, 1905; probably only in drift, and it is just about in the line of the ice motion from the Bay county fields; Montrose township, Genesee county, L. C. Crompton, at 230 feet, Detroit Journal, Oct. 28, 1905; Nashville, July 19, 1905; two miles north of Standish, Detroit News, Oct. 30, 1905, at 94 feet.

from outside.[1] At best the development of our Michigan field is no bonanza to anyone and it is a pity to waste money on utterly hopeless endeavor, rather than put it where there is at any rate a ghost of a show.

I have said the drift covering makes not only slow and expensive exploration, but difficult shaft sinking. The very wealth of water which is a valuable asset for Michigan as a whole, has made the sinking of a shaft for rock salt near Detroit, and the sinking of coal shafts, often very hard. The Auburn Coal Co. have lost two shafts in quicksand. The highest grade of experience in handling water is needful for anyone who wants to mine in Lower Michigan.

No developments have indicated any coal seams very much younger than the horizon of the Upper Verne,—the Pottsville.[2] Apparently the Verne coals are more wide spread and tend to be poorer in quality on the whole, though higher in volatile combustible and more readily coking.

Analysis (1) is an analysis of a sample sent us by Mr. H. G. Wheaton[3] from the Carbon Coal Company's mine on the Thomas Mulvaney farm, east of Jackson.

The seam is said to be about 3½ feet thick, at about 45 feet depth with a poor soft roof and frequent clay slips. It was opened in 1904 by T. M. Johns & Son. From the amount of sulphur and the color of the "ash" it is practically iron oxide from sulphide of iron in the coal and there was no *clay* ash. Such a coal should be much improved by washing.

Some years ago H. J. Williams made for me some tests on coal from the Wenona mine to see how it would behave for washing and coking.

No. 2 is the analysis of the sample he received. It made a good coke, hard, silvery, resonant, which contained about 10.36% of ash and 2.11 of sulphur, showing that more than half the sulphur remained with the fixed carbon. Washing reduced the pyrite from 4.65% to 2.53% the slimes were 4.40% and the analysis of the washed and dried coal, assuming that the moisture was the same, is given in analysis No. 3. We also give analysis (4) by Prof. G. A. Koenig of coal from the same mine and one by D. P. Shoner (5) of the coke. Dr. Koenig reported that with *hot* ovens it would lose more S. and make a blast furnace coke and classed 56.80 of it as coke, 42.11 as gas and tar, 1.09 moisture.

I should not feel that I was fair to the State in printing an analysis of the Jackson coal, which was one of the first coals developed, and the quality of which was long deemed so representative of Michigan coal that it has given its reputation a black eye hard to remove, without also putting beside it some analyses of a better seam, and I have chosen for that purpose analysis of the Saginaw seam at St. Charles made by F. S. Kedzie, published by the Robert Gage Coal Co.; (6), and one from the What Cheer Coal Mining Co. (7), which we have not hitherto published.

[1] Sanilac county.
[2] See Volume VIII, part 2, pp. 42-47.
[3] May 16, 1905.

COAL ANALYSES.

Number	1.[1]	2.[1]	3.[1]	4.[1]	5.	6.[2]	7.[2]
Location	East of Jackson.	Wenona.	Wenona washed.	Wenona G. A. K.	Wenona coke.	Robert Gage.	What Cheer.
Moisture	5.67	3.78	3.78	1.09	1.68	2.37	2.864
Volatile comb	45.06	41.18	41.40	42.11	3.12	35.67	} 91.283
Fixed carbon	43.85	49.34	50.48	50.89	79.46	58.47	
Ash	5.42	5.70	4.34	5.91	15.74	2.46	5.853
Sum	100.000	100.000	100.000	100.000	100.000	100.000	100.000
Total S	5.16	2.50	1.82	1.95	1.41	1.03	.128
Iron				1.71			
Fe_2O_3 from S	5.98						
Clay calculated	.00	3.57		3.41			
Pyrite calculated	10.58	4.67	3.41	3.66			
Corrected C. fixed carbon	} 83.75	87.98					
Hydrocarbon							
Coke		55.04		56.80			
P					.01		
C				72.74			
H				5.27			
N				1.51			
O				12.26			
Obs. Calorimet Parr	12.989					13.438	
Lane (146.6 (f+v) + 40 S)[3]	12.500						

[1] Verne seam.
[2] Saginaw seam.
[3] See Volume VIII, part 2, p. 120, Coal of Michigan, by A. C. Lane.

The following set of analyses of drillings through the Verne coal are of interest, because they give some idea of the distribution of the sulphur and ash in the different parts of the seam, and help to show how persistent the relatively high percentage of volatile matter and low percentage of moisture (good points) and large amount of ash and sulphur as compared with the Saginaw seam (bad points) are:

COAL DRILLINGS IN THE VERNE COAL.

Number	8.	9.	10.	11.	12.	13.
Location	No. 7 6″ to 3′	No. 23 0″ to 6″	No. 23 4″ to 1′10″	No. 23 1′10″ to 4′4″	No. 20 0′ to 7″	balance 7″ to 3′8″
Moisture	1.74	0.71	0.92	0.87	1.49	6.27
Volatile comb	44.70	40.57	42.25	40.22	42.45	42.78
Fixed carbon	44.81	42.30	44.68	40.33	36.70	41.19
Ash	5.61	14.12	9.57	15.34	15.88	6.98
Total S	3.15	2.21	2.59	3.24	3.49	2.78
Sum	100.000	100.000	100.000	100.000	100.000	100.000

G. B. WILCOX.

I trust that these gleanings from our note books and records giving glimpses of the manifold development of our raw materials may be of enough current value and interest to warrant the brief notice I have given. But of course our chief work lies in the larger and more formal papers with maps, etc., which you allow me to submit independently, so as to make more clear the credit and the identity of each author.

To them and to all my fellow employes and many others my thanks are due.

Very respectfully,

ALFRED C. LANE.

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